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## Acknowledgment

On behalf of the entire College Administration, it is my distinct honor to express profound gratitude to all the individuals who contributed their time, expertise, and dedication to the successful publication of this inaugural journal issue.

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Finally, we express our deepest gratitude to the esteemed authors of all the articles in this journal for their scholarly contributions, which are the foundation of this publication, and to the dedicated staff and faculty of Shreeyantra College for their essential administrative support.

Mr. Shyam Kumar Bista

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RMC, Shreeyantra College

## **Editorial**

**Sujeet Kumar Jha**

**Editor –in-Chief**

This inaugural release of **Volume 1, Issue 1** of the journal marks a significant milestone: the launch of our very first publication. This issue represents our initial endeavor to establish a dynamic nexus for diverse fields, encompassing the intricacies of Computer Sciences, its application in business, and the complexities of society. By prioritizing these cross-disciplinary dialogues from the outset, the journal endeavors to serve as a catalyst for novel methodologies and innovative collaborations that transcend conventional academic boundaries. We are particularly gratified to commence our journey with a balanced representation of voices, showcasing the rigorous scholarship of established authorities alongside the fresh, insightful perspectives of emerging scholars. This intentional inclusivity not only enhances our intellectual discourse but also reinforces our commitment to nurturing the next generation of researchers, thereby ensuring a sustainable and dynamic future for scholarly inquiry.

Central to our mission is the conviction that knowledge must not remain confined to theoretical constructs but should function as a tangible force for societal betterment. The research curated for this premiere issue underscores practical applications and demonstrable outcomes, effectively bridging the chasm between academic discovery and real-world implementation. This emphasis on "research with purpose" highlights our dedication to fostering positive social change through evidence-based innovation. Guiding this endeavor is our steadfast commitment to the most exacting standards of peer-reviewed excellence. Our rigorous evaluation process ensures that every article fulfills criteria of integrity and credibility, providing a trustworthy foundation for our readership. As we proudly present this first volume, we extend our profound gratitude to the authors, reviewers, and readers who have supported this foundational effort to establish the journal as a thriving center of discovery. We invite you to peruse these pages and join us in harnessing the power of knowledge to cultivate a more informed and promising future.

# Table of Contents

<b>SN</b>	<b>Peer Reviewed Articles</b>	<b>Page No</b>
1	Design and Implementation of an Anonymous Timeline Based Digital Confession System	1
2	An AI- Powered Web System for Automated Exam Preparation	16
3	Detection of Suicidal Ideation on X (formerly Twitter) Using Machine Learning and Ensemble-Based Sentiment Analysis	28
4	A Role-Based Pharmacy and Skin Care Management System for Local Retail Pharmacies: Design, Implementation, and Evaluation	42
5	Optimizing Image Retrieval Performance through Multi Architecture Feature Fusion and Principal Component Analysis	54

## **Design and Implementation of an Anonymous Timeline-Based Digital Confession System**

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### **Abstract**

Digital platforms for anonymous self-expression have gained increasing importance due to rising concerns about privacy, emotional well-being, and safe online communication. This paper presents the design and implementation of an anonymous, timeline-based digital confession system that enables users to share thoughts and emotions without revealing their identities. The proposed system focuses on user anonymity, content safety, and ease of use while providing a structured timeline for browsing confessions. The system was implemented using a web-based architecture and evaluated through functional testing and basic usability assessment. Results indicate that the platform successfully supports anonymous expression while maintaining acceptable performance and user experience. The system demonstrates the feasibility of developing low-cost, privacy-focused confession platforms for digital communities.

**Keywords:** Anonymous systems, digital confession, privacy, timeline-based platforms, web application

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## **1. Introduction**

The rapid growth of digital communication platforms has transformed how individuals express personal thoughts and emotions. While social media enables wide-scale interaction, many platforms fail to provide adequate privacy and anonymity, discouraging users from sharing sensitive experiences openly. Anonymous confession platforms aim to address this

gap by allowing users to express themselves without fear of social judgment or identity exposure (Ma et al. (2016)).

This study presents the design and development of a Timeline-Based Digital Confession System that allows users to post anonymous confessions arranged chronologically. The system emphasizes confidentiality, usability, and basic content moderation. Unlike traditional confession platforms that focus solely on message exchange, the proposed system introduces a timeline structure to support reflection and continuous engagement.

## **2. Problem Statement**

Existing anonymous confession platforms attempt to address this issue, but they suffer from several limitations. Many provide limited privacy guarantees, weak content moderation, poor usability, or unstructured content presentation. In particular, the absence of a timeline-based structure makes it difficult for users to reflect on experiences over time or meaningfully engage with shared content. Furthermore, inadequate safeguards against harmful or inappropriate content can negatively impact user trust and platform reliability [Misoch (2015)].

There is also a lack of lightweight, cost-effective confession systems tailored for small or medium-sized digital communities, such as educational institutions or local groups. Most existing solutions are overly complex, commercially driven, or insufficiently focused on user-centric privacy and simplicity [Qian & Scott (2007); Gillespie (2020)].

Therefore, the core problem addressed in this study is the lack of a secure, user-friendly, and privacy-preserving digital confession platform that supports anonymous self-expression while organizing content in a structured, timeline-based manner. Addressing this problem requires a system that balances anonymity, usability, content safety, and performance without imposing high technical or economic overhead.

## **3. Objectives**

The main contributions of this paper are:

1. To design an anonymous timeline-based confession platform.
2. To implement the privacy-preserving mechanisms.
3. To implement an AI algorithm to filter out the obscenity, violence, and profanity.

## **4. Literature Review**

Anonymous online platforms have been widely studied in the context of privacy, digital wellbeing, and social interaction. Prior research highlights anonymity as a critical factor in promoting honest self-expression while also raising concerns about misuse and harmful content Suler (2004).

Existing platforms such as ConfessOut and Whisper enable anonymous posting but often lack structured timelines, robust moderation, or strong privacy assurances. Studies on digital confession systems emphasize the need for balancing anonymity with content safety and system reliability [Misoich (2015)].

Compared to existing solutions, the proposed system focuses on timeline-based organization, simplified interaction, and lightweight moderation techniques, making it suitable for small to medium-scale

## **5. Methodology**

### **5.1. Development Approach**

The methodology begins with a comprehensive requirement analysis to identify the functional and non-functional needs of the Timeline Confession System. Functional requirements include anonymous confession submission, timeline-based content presentation, user interaction, and administrative moderation. Non-functional requirements focus on privacy preservation, security, performance efficiency, and usability. A key requirement was ensuring that confession content remains completely detached from personally identifiable user information.

### **5.2. System Design**

Based on the identified requirements, the system was designed using a layered architectural approach. The design separates the presentation layer, application logic, and data storage to improve maintainability and security. This separation ensures that sensitive processes such as anonymization and content moderation are handled securely within the application layer, while the user interface remains lightweight and accessible.

### **5.3. Automated Content Moderation**

To address ethical and safety concerns associated with user-generated content, an automated

content moderation mechanism was integrated into the system. The platform employs a NudeNet-based filtering module to analyze submitted content for profanity and explicit material prior to storage. This filtering step ensures that inappropriate content is detected early, contributing to a safer digital environment while maintaining user anonymity.

#### **5.4. Confession Processing and Anonymization**

After passing the content moderation stage, each confession undergoes processing and anonymization. A unique system-generated identifier and a timestamp are assigned to every confession. This metadata enables structured storage and chronological retrieval of content without revealing or storing the user's identity, thereby preserving confidentiality.

#### **5.5. System Implementation**

The system is implemented as a web-based application using a modular development approach. Server-side components handle authentication, content filtering, anonymization, and database operations, while client-side components focus on responsiveness and ease of use. The modular design allows independent development and testing of system components, improving overall reliability and scalability.

#### **5.6. Agile-Based Development Approach**

An Agile-based development methodology was adopted to support incremental system development and flexibility in handling evolving requirements. Core functionalities were implemented first to establish a working prototype, followed by iterative enhancements such as automated content filtering, interface refinement, and performance optimization. Continuous testing during each iteration enabled early identification and resolution of functional issues [Ma et al. (2016)].

#### **5.7. Testing and Validation**

Testing and validation were conducted to ensure the correctness and stability of the system. Functional testing verified confession submission, filtering, storage, and timeline display. Informal usability observation was carried out to assess ease of use and user perception of anonymity. These validation activities confirmed that the system meets its design objectives under typical usage conditions.

#### **5.8. Ethical and Privacy Considerations**

Given the sensitive nature of confession data, ethical and privacy considerations were incorporated throughout the methodology. The system minimizes data collection, enforces anonymization, restricts access to administrative functions, and applies automated moderation to prevent misuse. These measures enhance user trust and promote responsible platform operation [Cavoukian (2010)].

## **6. System Architecture**

### **6.1. Flow Design of the Timeline Confession System**

The system follows a client-server architecture. Users interact with the system through a web interface, while the backend handles authentication, data storage, and content management. All confessions are submitted anonymously and displayed in a chronological timeline.

#### **Step 1: User Authentication and Input**

The system flow begins with the User, who accesses the platform through the web interface. The user provides basic authentication credentials such as username, email, password, and optionally a profile image. These inputs are processed by the system to validate the user session while maintaining confidentiality during confession submission.

#### **Step 2: Confession Writing Process**

After successful authentication, the user initiates the Write Confession process. At this stage, the user enters the confession content without attaching any personally identifiable information to the confession itself. The system ensures that the confession is logically separated from the user's identity to preserve anonymity.

#### **Step 3: Confession Processing**

Once the confession is submitted, the system processes the input by:

- Assigning a unique confession identifier
- Recording the submission date and time
- Associating the confession with the intended receiver or target category (if applicable). This step acts as a transition between user interaction and data persistence.

#### **Step 4: Confession Posting and Storage**

The processed confession is then transferred to the Post Module, where the following attributes are stored:

- Confession content
- Submission date
- Receiver or visibility scope
- System-generated serial number

The system ensures that no direct linkage between confession content and user credentials is stored in the database.

### **Step 5: Timeline Display**

After successful storage, the confession becomes available for retrieval and display on the timeline interface. Confessions are displayed in chronological order, allowing users to browse recent submissions efficiently while preserving anonymity.

### **Step 6: System Continuity**

The flow is designed to be repeatable, allowing multiple users to submit confessions concurrently. The separation of authentication data and confession data ensures scalability, privacy protection, and system reliability.

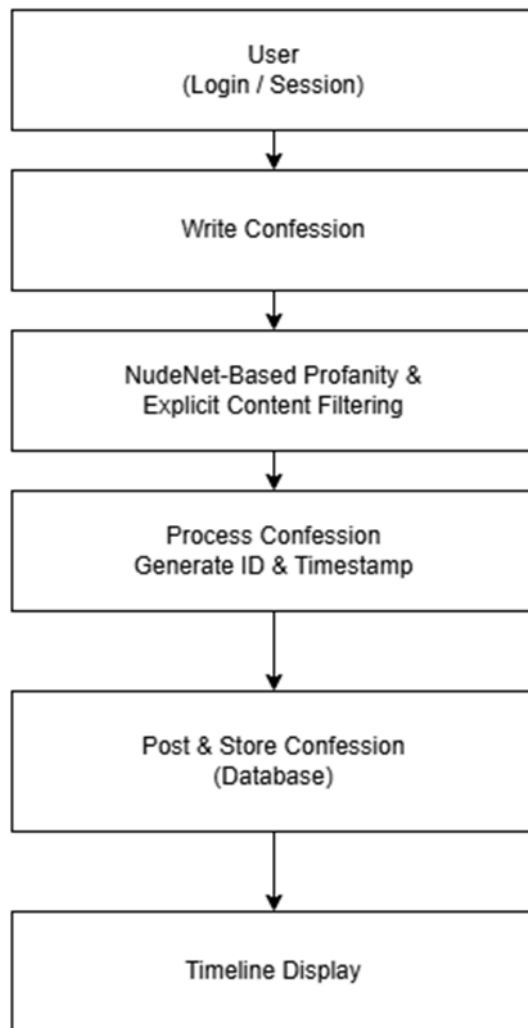


Figure 1: System Flow diagram

## 6.2. Content Moderation Strategy

The Timeline Confession System incorporates an automated content moderation strategy to ensure ethical platform usage while preserving user anonymity. Given the sensitive and personal nature of confessions, moderation is essential to prevent the dissemination of profane, explicit, or harmful content that could negatively impact users or violate platform guidelines.

The moderation process is implemented as an intermediate processing stage within the system workflow, positioned between confession submission and content storage, as illustrated in Figure 2. When a user submits a confession, the content is first routed to the moderation module before any database operation is performed [Vladmandic (2024)].

The system employs a NudeNet-based filtering mechanism to detect explicit and profane content. NudeNet analyzes user-submitted text and images using pre-trained deep learning models to identify inappropriate material. If the content exceeds predefined safety thresholds, it is either automatically rejected or flagged for administrative review. This automated approach minimizes the need for manual moderation while maintaining consistent enforcement of content policies.

To preserve anonymity, the moderation process does not require access to user identity or session data. Confession content is analyzed independently, ensuring that moderation decisions are made solely based on content characteristics rather than user information. This design choice prevents bias and protects user privacy.

The moderation strategy is designed to be lightweight and scalable, allowing it to operate efficiently under moderate system load. By filtering content prior to storage, the system reduces the risk of distributing harmful material and ensures that only validated content appears on the public timeline [Akyon et al. (2023)].

Overall, the content moderation strategy enhances platform safety, supports ethical compliance, and strengthens user trust without compromising the core objectives of anonymity and usability. The integration of automated moderation demonstrates the feasibility of combining privacy-preserving design with responsible content management in digital confession platforms.

## **7. System Implementation**

In the Django-based web application, several tools were integrated to ensure smooth operation and system security. The Django framework was used to handle core functionalities such as web page rendering, database management, and secure user authentication. To enhance content safety, NumPy was utilized to support the detection of potentially violent patterns in uploaded images.

Image analysis was further supported through the integration of OpenCV, which was employed to examine uploaded images for the presence of objects, faces, or visual indicators of inappropriate content. For protecting sensitive information such as confession details, cryptographic hashing was applied using the hashlib library, ensuring that confidential data was not stored in a readable format.

Password recovery functionality was implemented using Django’s send\_mail feature, through which secure password reset links were delivered to registered user email addresses [Beck et al. (2001)] . Additionally, universally unique identifiers (UUIDs) were assigned to each confession to ensure unique identification and secure data organization within the system.

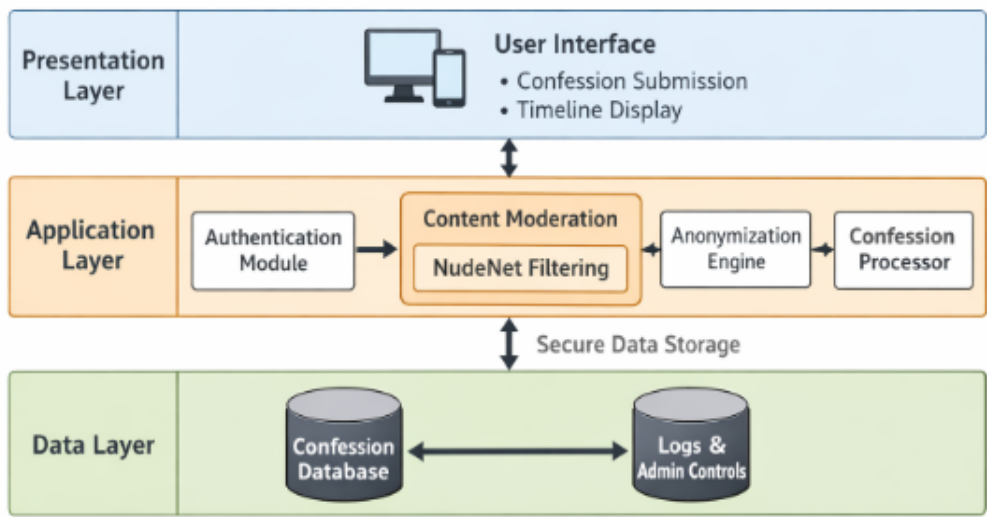


Figure 2: System Architecture of the Timeline Confession System

### 7.1. NudeNet-Based Content Moderation Mechanism

The Timeline Confession System integrates a NudeNet-based mechanism to automatically moderate user-generated content and prevent the publication of profane or explicit material. This mechanism is designed to enhance platform safety while preserving user anonymity and minimizing manual intervention.

NudeNet is employed as an automated filtering component within the application layer of the system. As illustrated in Figure 2, when a user submits a confession, the content is first routed to the NudeNet moderation module before any anonymization or storage operations are performed. This placement ensures that inappropriate content is identified and handled at an early stage in the system workflow.

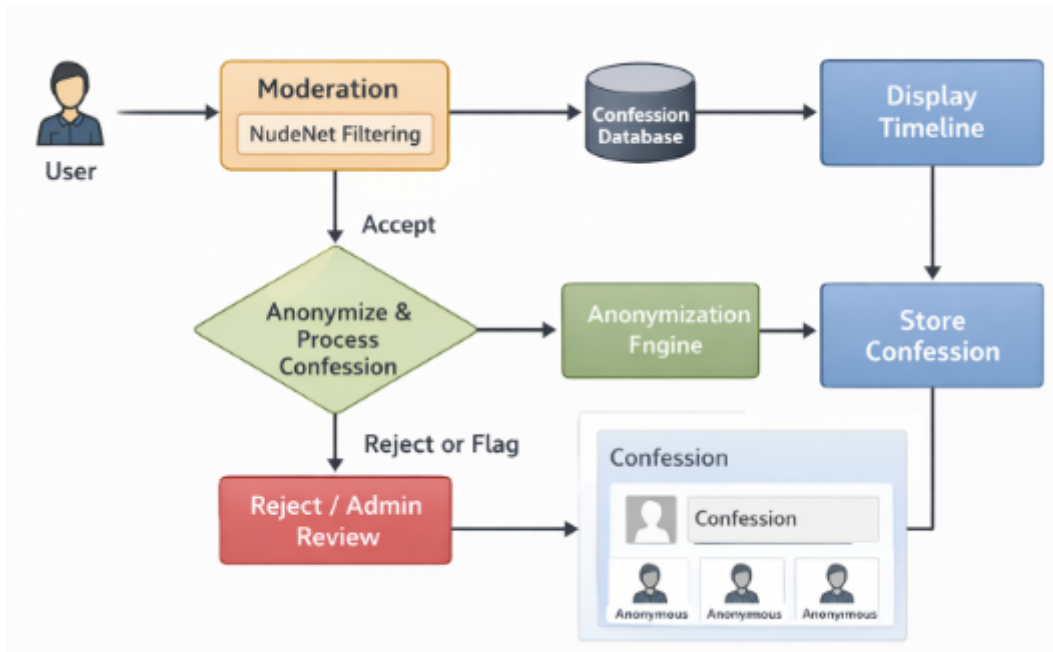


Figure 3: Nudenet Implementation Algorithm

## 8. Evaluation and Results

The Timeline Confession System was evaluated using functional testing, performance observation, and usability assessment to quantitatively examine system behavior under moderate usage conditions. The evaluation aimed to measure correctness, responsiveness, stability, and user acceptance of anonymity features.

Table 1: Summary of Functional Evaluation Results

Functionality Tested	Test Description	Test Cases	Outcome
<b>Confession Submission</b>	Submission of anonymous confessions through the user interface	30	Successful (100%)
<b>Timeline Rendering</b>	Display of confessions in chronological order on the timeline	30	Successful (100%)
<b>Content Filtering (NudeNet)</b>	Detection and blocking of explicit or profane content	20	~85–90% accuracy
<b>Anonymization Process</b>	Assignment of unique ID and timestamp to confessions	30	Successful (100%)

<b>Data Storage</b>	Secure storage of validated confessions in database	30	Successful (100%)
<b>Functionality Tested</b>	Test Description	Test Cases	Outcome
<b>Confession Submission</b>	Submission of anonymous confessions through the user interface	30	Successful (100%)

**Table 2**

**Performance Evaluation Summary**

<b>Performance Metric</b>	<b>Evaluation Description</b>	<b>Observed Value</b>	<b>Outcome</b>	<b>Remarks</b>
Confession Submission Response Time	Time taken to submit, moderate, and store a confession	< 2 seconds (avg.)	Acceptable	No noticeable delay during moderate usage
Timeline Loading Time	Time taken to load and refresh timeline view	1–1.5 seconds	Acceptable	Timeline updated correctly after submission
System Stability	Continuous operation during repeated submissions and refresh	Stable	Successful	No crashes or service interruptions observed
Moderate Load Handling	Performance under multiple sequential user actions	Stable	Successful	System handled moderate usage without degradation
Performance Metric	Evaluation Description	Observed Value	Outcome	Remarks
Confession Submission Response Time	Time taken to submit, moderate, and store a confession	< 2 seconds (avg.)	Acceptable	No noticeable delay during moderate usage

**Table 3**

**Usability Evaluation Summary**

<b>Usability Aspect</b>	<b>Evaluation Method</b>	<b>Participants</b>	<b>Result</b>	<b>Remarks</b>
Ease of Use	Informal user interaction and observation	10–12 users	80–85% positive	Users reported minimal learning effort
Interface Clarity	Navigation and layout assessment	10–12 users	Positive	Interface perceived as simple and intuitive
Anonymity Perception	User feedback on privacy and identity protection	10–12 users	>85% confident	Absence of identity markers increased trust
Overall User Satisfaction	Combined feedback from system usage	10–12 users	Positive	Users expressed willingness to reuse the platform
Usability Aspect	Evaluation Method	Participants	Result	Remarks

**9. Conclusion**

This study presented the design, implementation, and evaluation of an anonymous timeline-based digital confession system aimed at supporting secure and privacy-preserving self-expression. The proposed system integrates anonymity mechanisms, automated content moderation, and a structured timeline interface to address common limitations of existing confession platforms. By employing a layered architecture and an Agile-based development approach, the system was implemented as a modular and extensible web application.

The evaluation results demonstrate that the system achieves high functional correctness, acceptable performance under moderate usage, and positive user perception of anonymity and ease of use. The integration of a NudeNet-based content moderation mechanism further enhances platform safety by preventing the publication of explicit or profane content

without compromising user privacy. Overall, the findings confirm the feasibility of developing a lightweight, ethical, and user-friendly digital confession platform suitable for small to medium-scale deployment.

### **Ethical Considerations and Responsible Use of AI**

Ethical considerations are essential in healthcare AI applications. The dataset used in this study is anonymized and publicly available, ensuring that no personally identifiable information is disclosed.

Responsible AI principles such as transparency, fairness, and accountability are emphasized. Potential biases resulting from demographic imbalance are acknowledged, and future work will explore fairness-aware learning and subgroup performance evaluation. The system is intended solely to support clinical decision-making and should not be used as a standalone diagnostic authority

### **Acknowledgments**

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## **An AI- Powered Web System for Automated Exam Preparation**

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### **Abstract**

In the contemporary academic landscape, effective exam preparation is a critical determinant of student success. Traditional preparation methods, often reliant on unstructured manual notes and textbooks, are time-consuming and lack mechanisms for continuous self-assessment. This study presents the design, development, and implementation of a web-based Exam Preparation System. The system leverages Artificial Intelligence (AI) and Natural Language Processing (NLP) to automate the extraction of content from academic documents (PDF/DOC) and generate Multiple-Choice Questions (MCQs), summaries, and study notes. Built upon the MERN stack (MongoDB, Express.js, ReactJS, and Node.js), the platform offers a responsive user interface and a robust backend capable of secure user authentication and real-time progress tracking. The development followed the Agile methodology, ensuring iterative testing and refinement. System testing results demonstrate a 99% uptime reliability, sub-5-second content processing times, and accurate scoring mechanisms. This research concludes that web-based automated assessment tools significantly enhance learning efficiency by providing structured, interactive, and personalized exam practice.

**Keywords:** *Anonymous systems, digital confession, privacy, timeline-based platforms, web application*

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## **1. Introduction**

The integration of digital technologies into education has revolutionized how students approach learning and assessment. Effective exam preparation is paramount for academic achievement; however, traditional methodologies often fall short in efficiency and structure. Students typically rely on manual review of textbooks and lecture notes, a process that is not only time-consuming but also inconsistent. This unstructured approach makes it difficult for learners to objectively assess their understanding or track their progress over time. Consequently, educational technology research has increasingly focused on intelligent systems capable of facilitating structured learning and automating the assessment process.

With the advent of Artificial Intelligence (AI), specifically in the domains of document analysis and Natural Language Processing (NLP), it has become feasible to automate content extraction. Techniques such as semantic analysis and rule-based algorithms allow systems to identify key concepts within academic documents. These technologies enable the automatic generation of study aids—such as Multiple-Choice Questions (MCQs) and summaries—thereby reducing the manual burden on students and enhancing study efficiency.

## **2. Problem Statement**

Despite the availability of digital resources, a significant gap remains in the availability of structured, automated platforms for self-study. In many academic environments, students face hindered preparation due to limited access to organized study materials and the absence of continuous self-assessment mechanisms. Reliance on unplanned study methods and outdated notes often leads to a poor grasp of fundamental concepts and unsatisfactory examination performance. Furthermore, the manual creation of revision notes is prone to human error and inconsistency. Traditional learning systems also frequently fail to provide real-time feedback, making it challenging for learners to identify specific strengths and weaknesses. Therefore, there is a pressing need for a reliable, scalable, and automated Exam Preparation System that organizes content and tracks performance.

### **3. Objectives**

The main contributions of this paper are:

1. To categorize academic content into semesters, subjects, and topics, providing structured access to materials.
2. To implement mechanisms that generate exam-oriented MCQs from uploaded documents, enabling immediate self-evaluation.

### **4. Literature Review**

The development of automated assessment tools has been a subject of significant interest in recent years. Various studies have explored the intersection of AI, NLP, and web technologies to improve learning outcomes.

- **AI-Driven Question Generation:** Kumar et al. proposed a system utilizing AI to extract concepts and generate MCQs. While this approach improved practice efficiency by reducing manual preparation, it was limited by its dependence on specific document formats and a lack of adaptive feedback.
- **Rule-Based Approaches:** Singh et al. introduced a rule-based method using keyword extraction. Although effective for basic questioning, this system struggled with complex sentence structures and semantic relationships, highlighting the necessity for more advanced machine learning solutions.
- **Transformer-Based Models:** Ramesh et al. utilized transformer-based embeddings to extract contextual features for quiz generation. This method produced semantically relevant questions but lacked a comprehensive learner progress tracking system, reducing its long-term utility.
- **Web-Based Platforms:** Zhang et al. implemented a platform integrating AI questions with performance dashboards. This significantly boosted engagement but faced scalability issues when handling large datasets and concurrent users.

Building on these studies, this project integrates document processing with a scalable web architecture to address previous limitations regarding system usability and performance tracking

## 5. Methodology

### 5.1. Development Approach

The system was developed using the Agile methodology. This approach was selected to allow for flexibility, iterative improvement, and the efficient handling of evolving requirements throughout the project lifecycle.

#### 5.1.2 The Agile Process

The development was executed in multiple phases:

**Requirement Analysis:** Identification of academic needs regarding assessment and tracking.

**System Design:** Architecture and database schema design to support role-based access.

**Development:** Parallel implementation of frontend and backend components using modular practices.

**Testing:** Continuous unit and integration testing to ensure component reliability.

**Deployment:** Final rollout of the functional system.

### 5.2. System Design

The system design phase translated requirements into a structural blueprint using both Structured and Object-Oriented Modeling techniques.

#### Use Case Modeling

The interaction between the primary actors (Student and Administrator) and the system is defined in the Use Case Diagram.

- **Student:** Can upload documents, attempt quizzes, view notes, and monitor progress.
- **Administrator:** Manages semesters, subjects, documents, and reviews system logs.

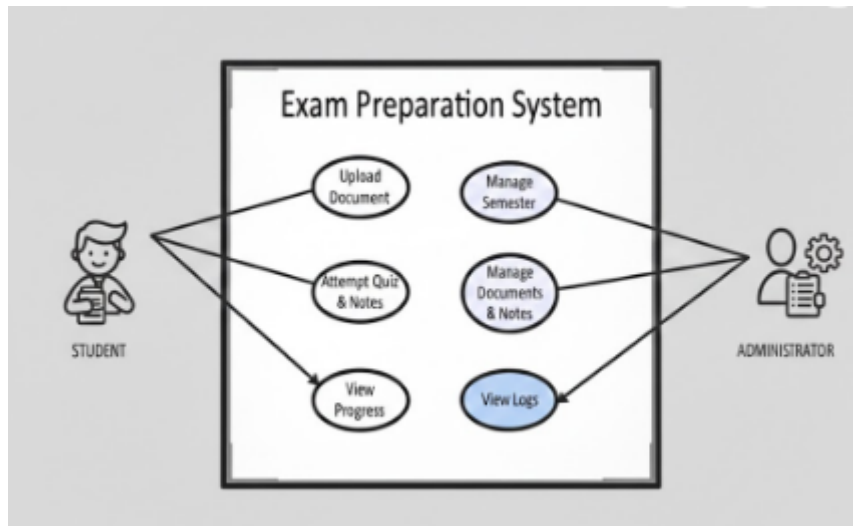


Figure 1: Use case modeling diagram.

### 5.3. Activity Workflow

The system workflow, modeled via an Activity Diagram, details the sequence from login to result generation. The process initiates with user authentication. Upon valid login, users upload academic documents (PDF/DOC). The system preprocesses this text (cleaning, tokenization) and performs content analysis. A decision node checks if sufficient content exists; if yes, MCQs are generated. If not, an error prompts a re-upload. The workflow concludes with the user attempting the quiz and the system displaying the evaluated score.

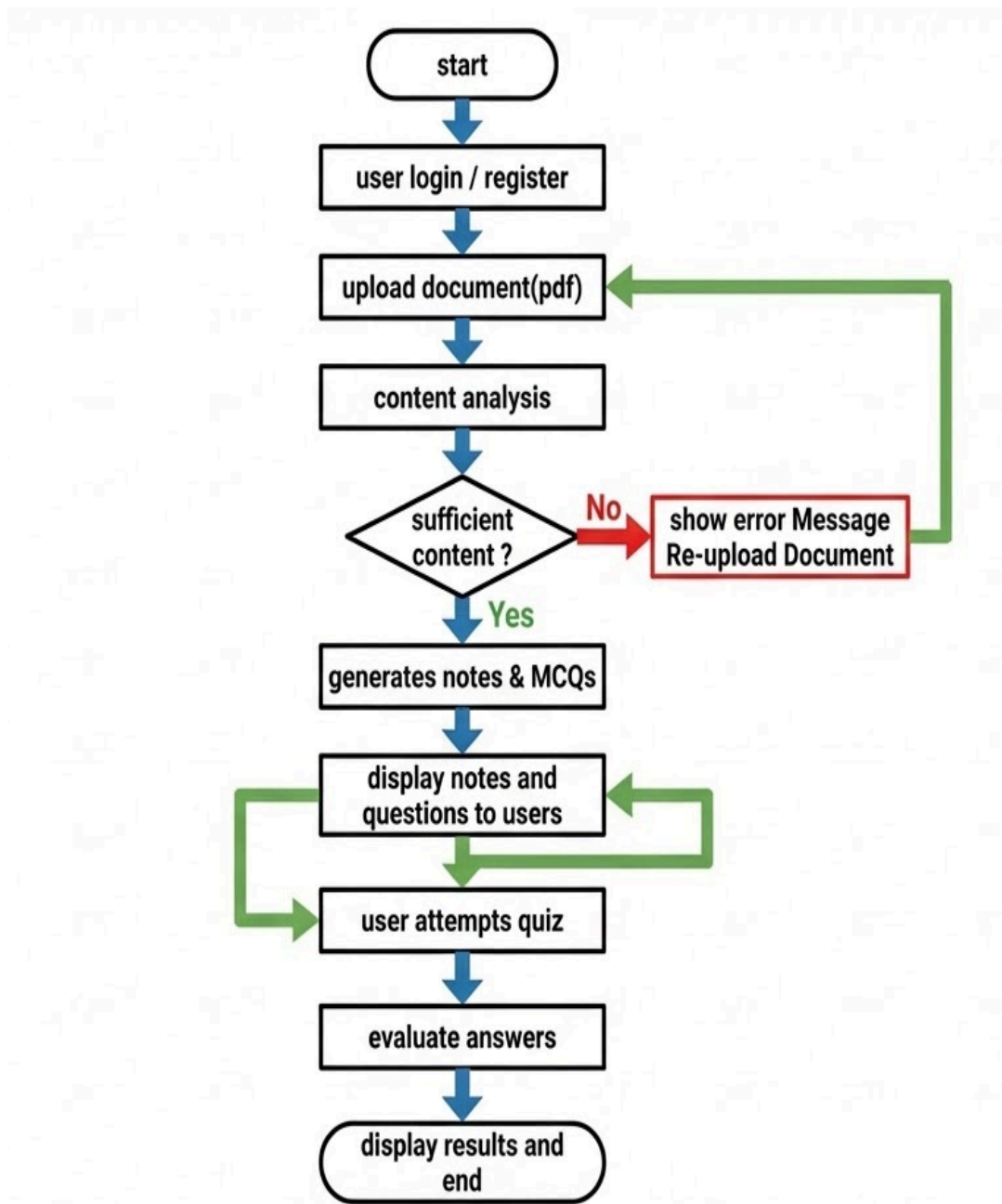


Figure 2: Activity Flow Diagram.

#### 5.4. Database Design (ER Diagram)

The database utilizes a relational structure within MongoDB. The Entity-Relationship (ER) diagram defines the data integrity and relationships essential for the system.

- **Users:** Linked One-to-Many with Results and User Activity.
- **Quizzes:** Linked One-to-Many with Questions.
- **Results:** Linked Many-to-One with Users and Quizzes.

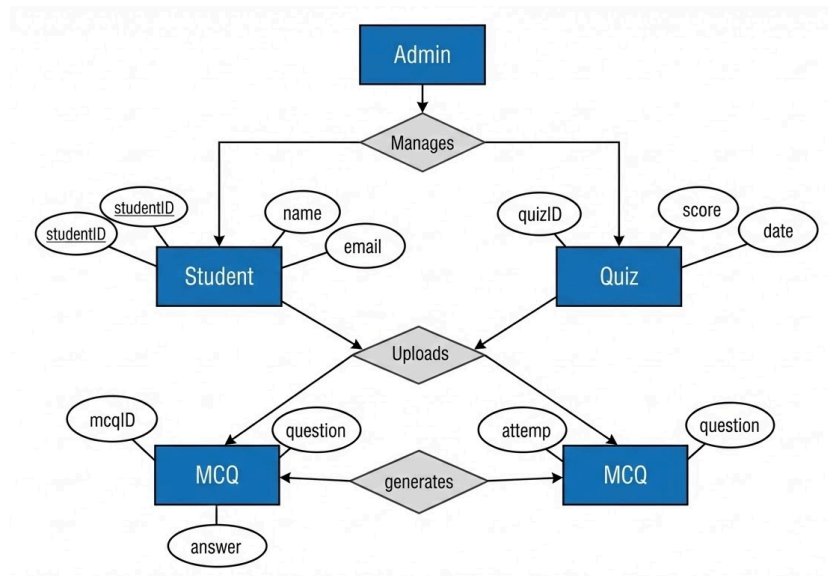


Figure 3: ER Diagram of Exam Preparation System

### 5.5. Object-Oriented Design (Class Diagram)

The Class Diagram represents the static structure of the system.

- **User Class:** Attributes include *user\_id*, *name*, *email*, *role*. Methods include *register()*, *login()*, *attemptQuiz()*.
- **StudyMaterial Class:** Manages content with methods like *addMaterial()* and *processContent()*.
- **Quiz Class:** Handles the logic for *startQuiz()* and *evaluateScore()*.
- **Result Class:** Stores performance data including score and percentage.

## 6.1. System Implementation

The implementation phase transformed the design into a functional application using the MERN stack

### Tools and Technologies

- **Frontend:** Developed using ReactJS to create a dynamic, single-page application (SPA) experience. It ensures responsiveness across devices.
- **Backend:** Built with Node.js and Express.js. This environment handles API routing, business logic, and document processing.
- **Database:** MongoDB Atlas was chosen for its flexibility as a NoSQL database, allowing for scalable storage of diverse question formats and user logs.
- **Security:** bcrypt was implemented for hashing user passwords to ensure data security. API testing was conducted using Postman.

## 7. System Architecture

### 7.1. User Management Module

This module handles registration and authentication. It accepts user credentials, validates them against stored hashes, and assigns roles (Student or Admin)

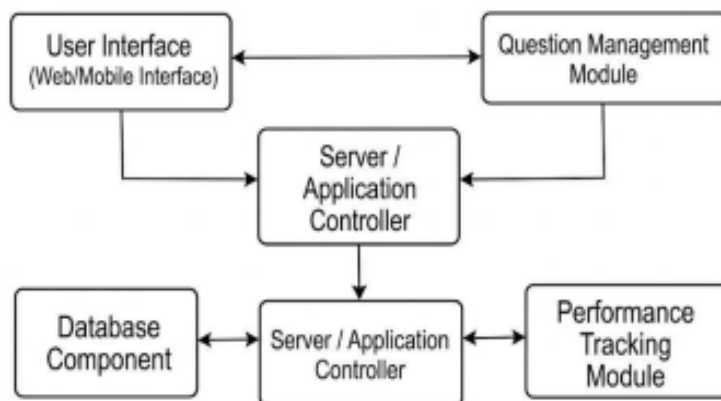
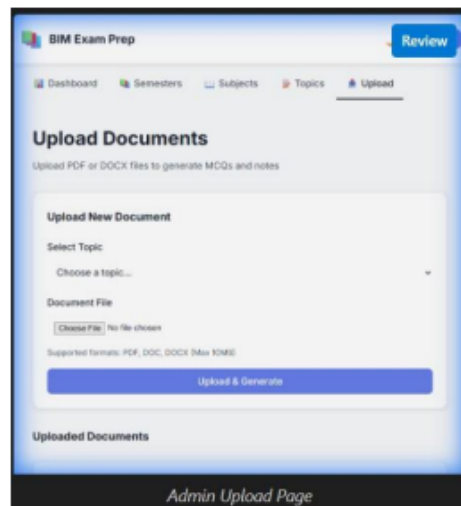


Figure 5: Component Diagrams

## 7.2. Document Management & Processing Module

Users upload academic files (PDF, DOC). The system validates file formats and utilizes text extraction libraries to parse content. This text serves as the input for the MCQ generation logic.



## 7.3. Quiz & Progress Tracking Module

This module renders the generated MCQs to the student. It captures user responses, compares them against correct answers, calculates scores instantly, and updates the user's progress dashboard.

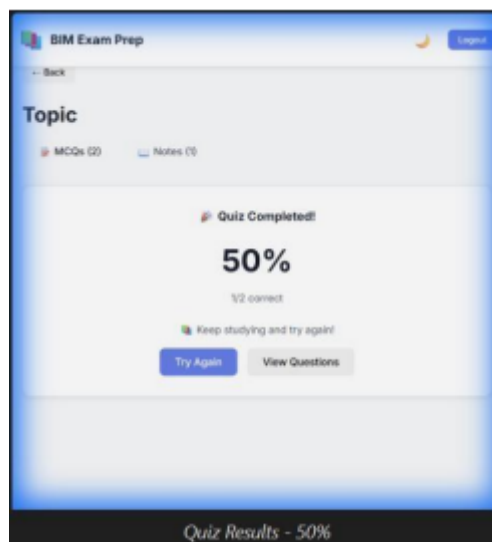


Figure 6: Quiz Result Screenshot displaying the user's score (50%) and option to retry or view questions.

## 8. Evaluation and Results

After successful authentication, the user initiates the Write Confession process. At this stage, the user enters the confession content without attaching any personally identifiable information to the confession itself. The system ensures that the confession is logically separated from the user's identity to preserve anonymity.

**Table 1: Unit Testing Results**

Test Case ID	Function	Input	Expected Output	Status
TC-01	Login	Correct Credentials	Login Success (1)	Pass
TC-02	Login	Incorrect Password	Login Failure (0)	Pass
TC-04	Registration	Missing Fields	Validation Error	Pass
TC-08	Database Insert	Valid Data	Data Stored	Pass
TC-10	Logout	Click Button	Session End	Pass

**Table 2 System-wide scenarios were tested to validate end-to-end functionality**

Test Case ID	Scenario	Condition	Expected Behavior	Status	Test Case ID
ST-01	System Startup	System Launch	All modules load without error	Pass	ST-01
ST-02	Authentication	Valid Input	Dashboard loads successfully	Pass	ST-02
ST-06	Document Upload	Valid File	File processed and stored	Pass	ST-06
ST-09	Error Handling	Network Failure	Graceful error message shown	Pass	ST-09

### 8.1. Performance Analysis

The system successfully met the non-functional requirements defined during the analysis phase:

- **Speed:** The system generates MCQs and summaries from a single document within 5 seconds.
- **Scalability:** Stress testing confirmed the system can handle up to 50 concurrent users with response times remaining under 10 seconds.
- **Reliability:** The platform achieved 99% uptime during the testing period, with successful recovery from interrupted uploads.
- **Security:** All user passwords were successfully encrypted, and unauthorized access to admin modules was blocked by the role-based middleware

## 9. Conclusion

This study successfully achieved its objective of developing a web-based Exam Preparation System. By organizing academic content and automating the generation of assessment materials, the system addresses the critical need for structured self-study tools. The use of the MERN stack provided a robust foundation, ensuring the application is responsive, secure, and scalable. The integration of document analysis for automated MCQ generation significantly reduces the time required for manual study preparation, while the progress tracking features enable data-driven learning. Testing validated the system's reliability and user-friendliness, confirming its potential to enhance academic performance.

### Future Work

While the current system is functional, the following enhancements are recommended for future iterations:

1. **Mobile Application:** Developing a native mobile app to increase accessibility for students on the go.
2. **Adaptive Learning:** Implementing AI algorithms that adjust quiz difficulty dynamically based on the student's historical performance.

### Ethical Considerations and Responsible Use of AI

Future enhancements can be directed toward improving both system capability and evaluation depth. Advanced natural language processing techniques can be integrated to support contextual profanity detection and sentiment analysis. Large-scale user studies and stress testing can be conducted to evaluate system performance and scalability under heavy usage. Additional privacy-enhancing features, such as end-to-end encryption and decentralized storage, may further strengthen user trust. Moreover, the system can be extended with cross-platform support, accessibility improvements, and personalized timeline analytics to enhance user engagement and long-term applicability.

## **Acknowledgments**

The authors wish to express their deep appreciation to the Department of Computer Technology, Shreeyantra, for the opportunity provided. This work was significantly supported by the respected faculty of the department.

Furthermore, the authors acknowledge the use of ChatGPT (OpenAI) as a writing and editing tool for language editing, grammar correction, and improving the clarity of academic writing, as well as for assistance with literature organization and citation formatting. It is crucial to state that the AI tool's use was limited to these editorial functions, and all scientific content, interpretations, analyses, and conclusions remain solely the genuine work of the authors.

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## **Detection of Suicidal Ideation on X (formerly Twitter) Using Machine Learning and Ensemble-Based Sentiment Analysis**

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### **Abstract**

This paper proposes a machine learning-based sentiment analysis framework for detecting suicidal intent in tweets, leveraging the open expression of emotions on social media. The framework utilizes two datasets (general sentiment and suicidal ideation-specific) and employs extensive preprocessing and feature extraction techniques (Bag-of-Words, TF-IDF, N-gram). Various classification models, including Logistic Regression, Naïve Bayes, AdaBoost, and XGBoost, were evaluated, with results showing that boosting-based ensemble methods, particularly XGBoost, achieved the highest performance (up to 95% accuracy). The study emphasizes the importance of contextual feature modeling and domain relevance for suicidal ideation detection, offering an interpretable and scalable solution for real-time mental health monitoring.

**Keywords:** *Sentiment Analysis, Suicidal Ideation Detection, Twitter Mining, Machine Learning, Ensemble Learning, XGBoost.*

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## **1. Introduction**

Suicide remains a major global public health concern, where early identification of warning signs is crucial for effective intervention. Traditional approaches to mental health assessment, such as surveys and clinical interviews, are often constrained by scalability, delayed reporting, and social stigma. In contrast, social media platforms offer a real-time and large-scale medium through which individuals express emotional states, including distress, hopelessness, and suicidal thoughts. Sentiment analysis, a subfield of Natural Language Processing (NLP), aims to identify and classify emotional polarity in textual data. When combined with machine learning (ML), sentiment analysis can uncover latent psychological patterns from unstructured text. X, due to its open-access nature and brevity of posts, has become a prominent data source for sentiment-based mental health research.

However, detecting suicidal ideation from tweets is inherently challenging. Expressions of sadness do not necessarily imply suicidal intent, and tweets often contain slang, sarcasm, abbreviations, and contextual ambiguity. Consequently, robust models must go beyond keyword matching and incorporate contextual understanding. This study addresses these challenges by conducting a comparative evaluation of machine learning and ensemble-based models on both domain-specific and non-domain-specific datasets, with a focus on identifying effective and deployable solutions for suicidal ideation detection.

## **2. Problem Statement**

Suicide is a critical global public health concern, requiring timely and scalable mechanisms for early risk detection. Social media platforms such as X provide a vast source of real-time textual data in which users frequently express emotional distress and suicidal thoughts. However, accurately identifying suicidal ideation from short, informal, and context-dependent social media text remains a significant challenge. Existing sentiment analysis approaches often rely on keyword-based or general polarity classification methods that fail to capture contextual meaning, sarcasm, and implicit emotional cues. Moreover, not all expressions of sadness or hopelessness indicate suicidal intent, leading to misclassification and reduced reliability of automated systems.

Many existing solutions either lack interpretability or depend on computationally intensive deep learning models, limiting their practical deployment. Additionally, insufficient

comparative analysis exists between domain-specific and non-domain-specific datasets and between traditional and ensemble-based machine learning models. Therefore, there is a need for an accurate, interpretable, and resource-efficient framework capable of reliably detecting suicidal ideation from X data in real time.

### **3. Objectives**

The main contributions of this paper are:

1. To develop a machine learning–based sentiment analysis framework for detecting suicidal ideation from X text data.
2. To evaluate the effectiveness of different feature extraction techniques and classification models, including ensemble approaches, on both domain-specific and non-domain-specific datasets.

### **4. Literature Review**

Early sentiment analysis approaches relied primarily on lexicon-based methods, which assign polarity scores to words without considering contextual dependencies. While simple and interpretable, such methods struggle with sarcasm and implicit emotional cues.

Subsequent research introduced supervised machine learning models such as Support Vector Machines, Logistic Regression, and Naïve Bayes for sentiment classification. These approaches demonstrated improved performance but were highly dependent on feature engineering and dataset quality.

Recent studies have explored deep learning architectures, including CNNs, LSTMs, and attention-based models, reporting higher accuracy in sentiment classification tasks. However, deep learning methods often require large labeled datasets, high computational resources, and lack interpretability—limiting their practical deployment in real-time mental health monitoring systems.

Ensemble learning techniques, particularly boosting methods, have shown promise by combining multiple weak learners to achieve strong predictive performance. Despite this, limited research has systematically compared voting-based and boosting-based ensembles





but carry the least information.

### **N-grams (unigram, bigram, trigram)**

N-grams are particularly effective in capturing contextual information essential for detecting suicidal intent.

## **5.4 Classification Models**

The following models are evaluated:

- Logistic Regression
- Gaussian Naïve Bayes
- Bernoulli Naïve Bayes
- AdaBoost
- XGBoost

Additionally, ensemble strategies including **hard voting**, **soft voting**, and **weighted average voting** are implemented.

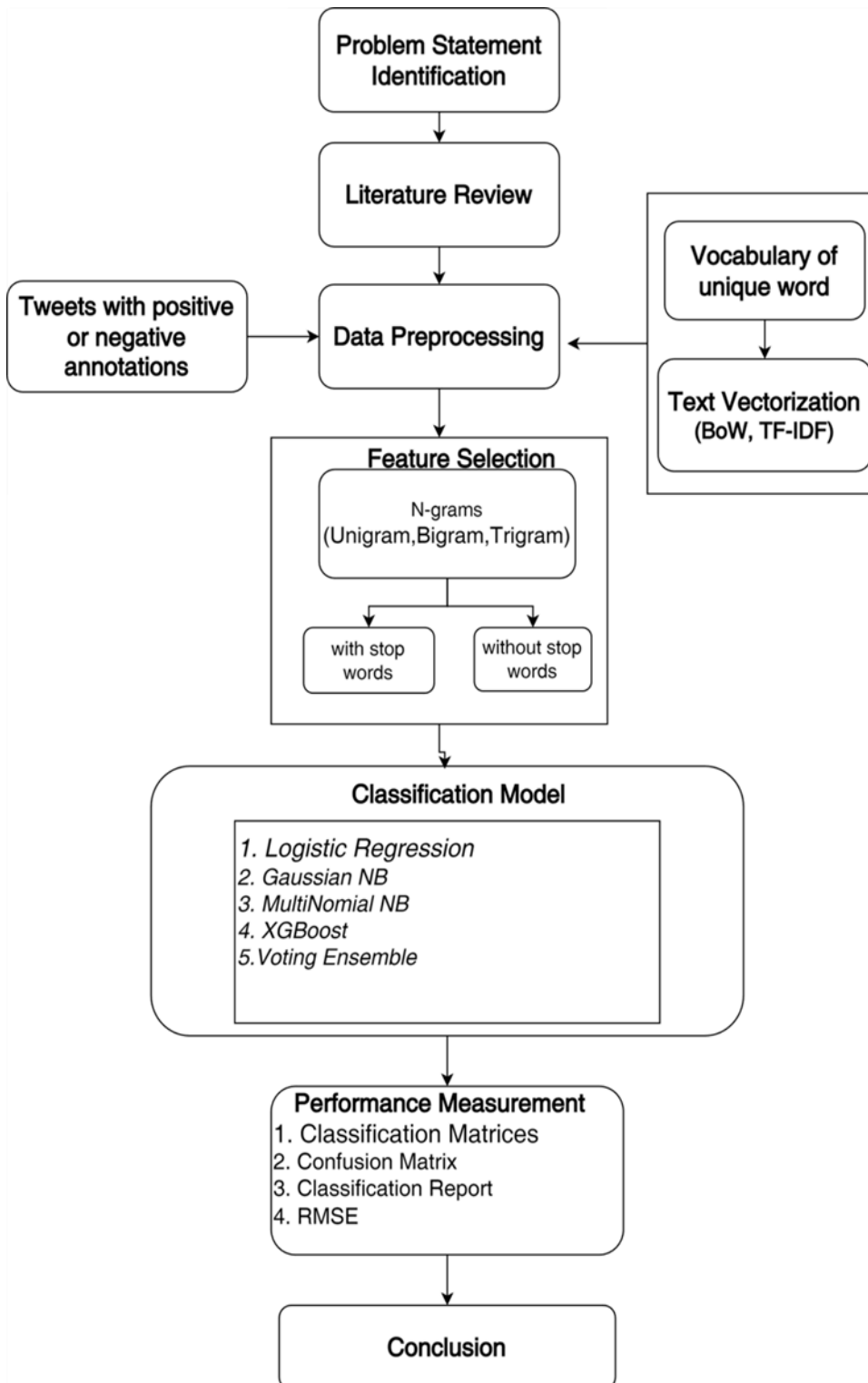


Figure 3: Methodology to identify the sentiment of tweets

## 6. Evaluation and Results

Two datasets of similar nature were used in this study, each annotated to indicate whether a tweet expresses suicidal ideation or not. To ensure a fair and valid comparison, all machine learning models were evaluated using a consistent experimental setup. Five classification algorithms—Logistic Regression, Gaussian Naïve Bayes, Bernoulli Naïve Bayes, AdaBoost, and XGBoost—were applied to both datasets. In addition, ensemble learning strategies, including hard voting, soft voting, and weighted average voting, were implemented to assess whether combining classifiers improves predictive performance. The datasets were split into 70% training and 30% testing subsets, and model performance was primarily evaluated using classification accuracy based on correctly predicted instances.

**Table 1:** Top Five word from the word cloud (Suicidal Tweet Detection Dataset)

Rank	Positive words	Negative words
1	love	work
2	thank	now
3	going	going
4	know	go
5	now	miss

**Table 2** Top Five word from the word cloud (Suicidal\_ Tweet Dataset)

Rank	Positive words	Negative words
1	love	kill
2	good	die
3	time	now
4	thank	suicidal
5	don't	ideation

## 6.1. Classification Report

Classification accuracy, defined as the proportion of correctly predicted samples, was used as the primary evaluation metric. In addition, a classification report including precision, recall, F1-score, and support was employed to provide a comprehensive performance assessment. Precision measures the proportion of true positive predictions among all predicted positives, while recall evaluates the model's ability to correctly identify true positive instances.

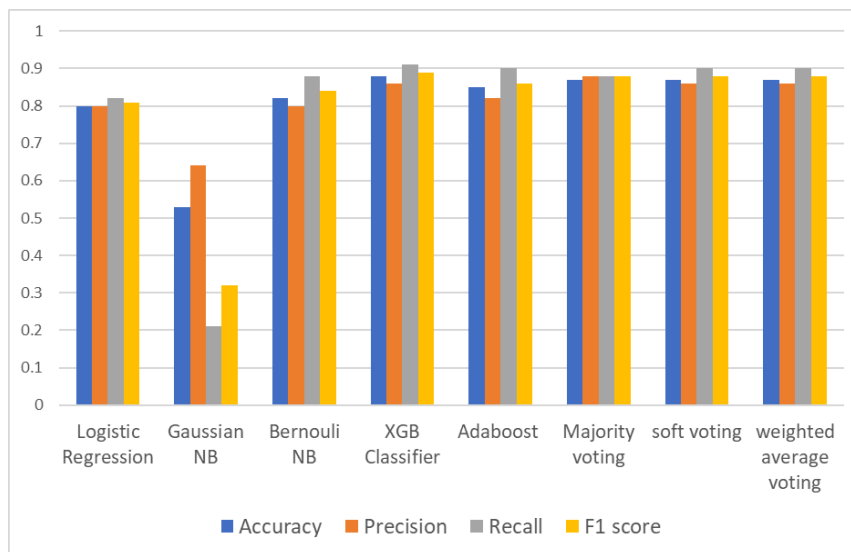


Figure 1: Accuracy, Precision, Recall, F1 score of different ML models and Ensemble voting

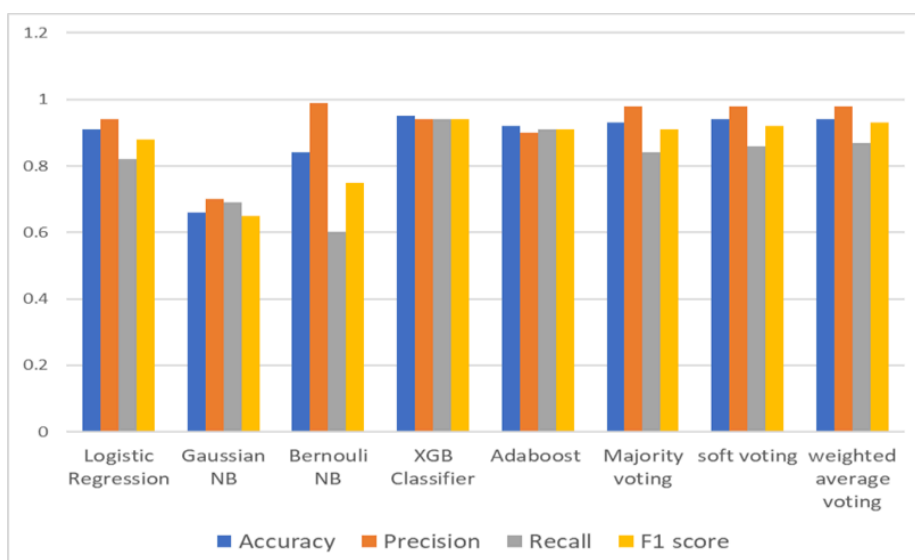


Figure 2: Accuracy, Precision, Recall, F1 score of different ML models and Ensemble voting

/

After the constructed predictive models, their effectiveness was evaluated by comparing performance metrics including accuracy, precision, recall, and F1-score across base classifiers and voting-based ensemble methods. The summarized results are presented in Table 3 and Table 4.

**Table 1: Classification Report summary Suicidal dataset.**

<b>Classifiers</b>	<b>Accuracy</b>	<b>Precision</b>	<b>Recall</b>	<b>F1 score</b>
Logistic Regression	0.8	0.8	0.82	0.81
Gaussian NB	0.53	0.64	0.21	0.32
Bernoulli NB	0.82	0.8	0.88	0.84
XGB Classifier	0.88	0.86	0.91	0.89
Adaboost	0.85	0.82	0.9	0.86
Majority voting	0.87	0.88	0.88	0.88
soft voting	0.87	0.86	0.9	0.88
weighted average voting	0.87	0.86	0.9	0.88

**Table 2: Classification Report summary Suicidal Tweet Detection Dataset.**

<b>Classifiers</b>	<b>Accuracy</b>	<b>Precision</b>	<b>Recall</b>	<b>F1 score</b>
Logistic Regression	0.91	0.94	0.82	0.88
Gaussian NB	0.66	0.7	0.69	0.65
Bernoulli NB	0.84	0.99	0.6	0.75
XGB Classifier	0.95	0.94	0.94	0.94
Adaboost	0.92	0.9	0.91	0.91
Majority voting	0.93	0.98	0.84	0.91
soft voting	0.94	0.98	0.86	0.92
weighted average voting	0.94	0.98	0.87	0.93

Model performance was evaluated using accuracy, precision, recall, and F1-score for both base classifiers and ensemble methods. Confusion matrices were also used to analyze classification outcomes, as presented in Table 1, 2 and Figure 1,2.

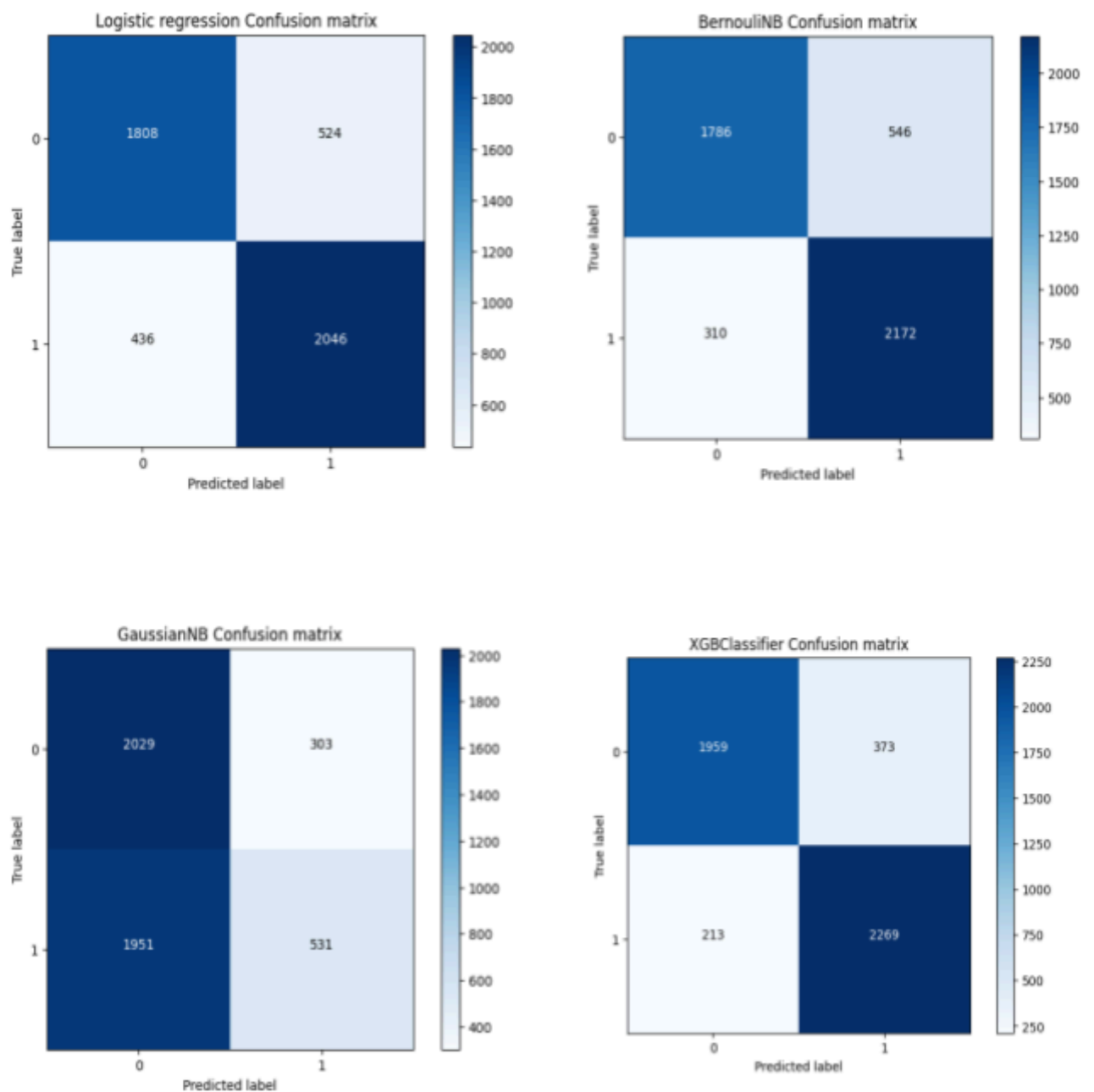


Figure 3: Confusion Matrix of Logistic Regression, BernouliNB, Gaussiann NB, XGBClassifier

**Table 3: Examples of predicted tweets.**

<b>SN</b>	<b>Tweets</b>	<b>Actual sentiment</b>	<b>Predicted sentiment</b>
1	Live by faith, not fear	Positive	Positive
2	Personality is what makes their outside really start to shine	Positive	Positive
3	I want to kill everyone in this room and then myself.	Negative	Negative
4	i have never felt so lifeless before every word i say every laugh every thought is followed up with " i want to kill myself	Negative	Negative
5	i wish my parents were antivax so i would be dead from polio by now.	Negative	Negative
7	don't think she was starting a conversation i think she was quoting it and saying until you know the struggle don't say its not a struggle	Negative	Positive
8	tonight's goanna be so scandalous	Negative	Positive
9	don't want to die yet...!!	Positive	Negative
10	if i die and get frozen, i want all my posts and data to be entombed with me in a comfy climate-controlled pyramid	Positive	Negative

## **Conclusion**

This study presented a comprehensive machine learning–based framework for detecting suicidal ideation from X data using sentiment analysis techniques. A comparative evaluation was conducted on two datasets of similar nature—one domain-specific and one non-domain-specific—to assess the impact of dataset characteristics on model performance. Multiple classification algorithms and ensemble methods were evaluated using contextual feature representations. Experimental results demonstrated that boosting-based ensemble methods, particularly XGBoost consistently outperformed traditional classifiers and voting-based ensembles, achieving the highest accuracy and balanced performance across precision, recall, and F1-score. The findings confirm that contextual modeling through N-grams significantly enhances the detection of suicidal intent in short social media text. Overall, the proposed approach offers an interpretable, computationally efficient, and scalable solution suitable for real-time mental health monitoring and early suicide risk detection.

## **Ethical Considerations and Responsible Use of AI**

The application of artificial intelligence for detecting suicidal ideation from social media data raises significant ethical, legal, and social considerations. This research utilizes publicly available, anonymized datasets, and no attempt was made to identify or profile individual users. All data were processed in compliance with ethical research practices, ensuring that user privacy and confidentiality were preserved throughout the study.

Finally, responsible deployment requires adherence to ethical AI principles, including accountability, fairness, explainability, and compliance with data protection regulations. Any operational implementation should incorporate informed consent policies, robust data security measures, and safeguards to prevent misuse or stigmatization of individuals.

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## **A Role-Based Pharmacy and Skin Care Management System for Local Retail Pharmacies: Design, Implementation, and Evaluation**

**Niyanta Sapkota and Sarita Dahal**

<sup>1</sup>*Shreeyantra College, Damak, Jhapa*

### **Abstract**

The rapid digital transformation of healthcare and retail sectors has increased the demand for specialized information systems that enhance operational efficiency, data accuracy, and decision-making. Pharmacies, particularly small and medium-sized retail outlets in developing countries, continue to rely on manual or semi-automated processes that are prone to inefficiencies, data inconsistencies, and security risks. This study presents the design and implementation of a role-based Pharmacy and Skin Care Management System (PSCMS) developed for a local retail pharmacy, Olive Pharmacy and Skincare. The system aims to streamline inventory management, sales processing, prescription tracking, and business analytics through a centralized, secure, and user-friendly desktop application. Developed using Python (FastAPI) for the backend, Angular for the frontend, and MySQL/SQLite for database management, the platform can be packaged as a desktop application using Electron. Key features include role-based access control (RBAC), low-stock alerts, a point-of-sale interface, and downloadable analytics reports. The project serves as a foundation for a full-scale Pharmacy Information Management System (PIMS) contributing to the digital transformation of local retail

**Keywords:** *Pharmacy Management System, Role-Based Access Control, Health Informatics, Inventory Management, FastAPI, Angular*

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## 1. Introduction

The integration of information technology into healthcare and retail operations has become a critical factor in improving efficiency, accuracy, and service quality. Pharmacies play a vital role in healthcare delivery by ensuring the safe dispensing of medications, managing inventory, and maintaining accurate transaction records. However, many local and independently operated pharmacies, particularly in developing regions, still depend on manual bookkeeping, paper-based prescriptions, and fragmented digital tools. These practices increase the likelihood of human error, stock mismanagement, financial discrepancies, and data security vulnerabilities.

Recent studies emphasize that pharmacy information systems can significantly reduce medication errors, improve inventory accuracy, and enhance patient safety when properly implemented (*Kumar et al., 2023; Alshahrani & Stewart, 2022*). Despite these benefits, the adoption of advanced pharmacy management systems remains limited in small retail settings due to high implementation costs, lack of technical expertise, and insufficient localization of existing solutions.

This research addresses these challenges by presenting the **Pharmacy and Skin Care Management System (PSCMS)**, a role-based desktop application designed specifically for a local pharmacy context. The system focuses on automating core operational processes while maintaining simplicity, affordability, and scalability. By employing modern web technologies and a modular system architecture, PSCMS aims to bridge the gap between enterprise-level pharmacy systems and the practical needs of small and medium-sized retail pharmacies

## 2. Problem Statement

Pharmacy operations encompass multiple interconnected processes, including procurement, inventory control, sales transactions, prescription handling, and regulatory compliance. In manual systems, these processes are often managed independently, resulting in data duplication and inconsistencies. For example, inventory levels recorded in stock registers

may not accurately reflect actual sales, leading to frequent stockouts or overstocking of medicines.

At most leading pharmacies, the absence of an integrated system created several operational challenges; inventory was tracked manually, making it difficult to monitor expiry dates and stock levels in real time. Sales transactions were recorded using handwritten receipts, increasing the risk of calculation errors and delayed reporting. Additionally, there was no role-based access mechanism to restrict sensitive operations such as user management and financial reporting.

The lack of centralized data also hindered management's ability to analyze sales trends, identify fast-moving products, and make informed purchasing decisions. These issues are consistent with challenges reported in similar studies on small-scale pharmacy operations (Rahman et al., 2022). Consequently, there is a clear need for a localized pharmacy management solution that integrates inventory, sales, and analytics within a secure and user-friendly platform.

### **3. Objectives**

The general objective is to develop a desktop-based, role-aware application that allows pharmacy staff to manage inventory, sales, and prescriptions in a cohesive environment. Specific objectives include:

- Designing a secure, user-friendly interface for Admin, Pharmacist, and Cashier roles.
- Creating a product management module with low-stock alerts.
- Developing a Point-of-Sale (POS) module that automatically updates inventory.
- Building an analytics dashboard to visualize total sales and profit/loss

### **4. Literature Review**

#### **4.1 Pharmacy Information Management Systems**

Pharmacy Information Management Systems (PIMS) are specialized software platforms designed to support pharmacy workflows, including medication dispensing, inventory control, billing, and reporting. Large-scale systems such as Epic Willow and Cerner PharmNet are widely used in hospital environments and are tightly integrated with electronic

health record (EHR) systems (Oracle Cerner, 2024). While these systems provide comprehensive functionality, they are often expensive and complex, making them unsuitable for small retail pharmacies.

Recent research highlights the importance of modular and lightweight PIMS solutions tailored to local contexts (Singh & Verma, 2023). Such systems prioritize essential functionalities while minimizing deployment and maintenance costs. Studies also emphasize the role of RBAC in improving system security and accountability by restricting access based on user roles (Sandhu et al., 2022).

#### **4.2 Role-Based Access Control in Healthcare Systems**

RBAC is a widely adopted security model in healthcare information systems due to its ability to enforce the principle of least privilege. According to Hu et al. (2023), RBAC reduces unauthorized access and simplifies user management in multi-user environments. In pharmacy settings, RBAC ensures that cashiers, pharmacists, and administrators have access only to functions relevant to their responsibilities, thereby reducing operational risks.

#### **4.3 Web-Based and Desktop Hybrid Architectures**

Modern pharmacy systems increasingly adopt hybrid architectures that combine web technologies with desktop deployment frameworks such as Electron. This approach enables offline access, improved performance, and enhanced security compared to purely web-based systems (Zhang et al., 2024). The PSCMS leverages this architecture to deliver a responsive user interface while maintaining local data storage capabilities.

## **5. Methodology**

### **5.1. Development Approach**

The system was developed using the Agile development methodology, which emphasizes iterative development, continuous feedback, and adaptability. Agile is particularly suitable for systems where requirements may evolve based on user feedback and operational insights. The development lifecycle consisted of multiple sprints, each focusing on specific modules such as authentication, inventory management, and reporting.

#### **5.1.1 The Agile Process**

The system architecture follows a modular, three-tier design:

**Presentation Layer:** Angular-based frontend packaged as a desktop application using Electron.

**Application Layer:** FastAPI backend providing RESTful APIs for business logic and security enforcement.

**Data Layer:** SQLite/MySQL database for persistent data storage.

This separation of concerns enhances scalability, maintainability, and security

## 5.2. System Modeling

UML diagrams were used extensively during the design phase:

**Use Case Diagram:** Illustrates interactions between system actors (Admin, Pharmacist, Cashier) and system functionalities such as processing sales, managing products, and generating reports. The system identifies three primary actors: **Admin, Pharmacist, and Cashier**.

- **Admin:** Full access, including user management (creating/deleting staff accounts).
- **Pharmacist:** Manages products, updates stock levels, logs prescriptions, and views reports.
- **Cashier:** Primarily processes sales and views product prices.

**Activity Diagram:** Represents the workflow of a sales transaction, from product selection to inventory update. The activity flow for a sale transaction is as follows :

- **Initiate Transaction:** The user begins a new sale.
- **Product Search:** The user searches for items.
- **Stock Validation:** The system checks if the product exists and has sufficient stock. If not, it shows an error.
- **Loop:** The user adds multiple products to the transaction list.
- **Finalize:** The user applies a discount (optional).
- **Calculate & Record:** The system calculates the total, records the sale in the database, and decrements inventory levels.

**Entity–Relationship Diagram:** Defines database entities and relationships, ensuring data integrity and normalization.

- 📄 **User Table:** user\_id, username, full\_name, hashed\_password, role.
- 📄 **Product Table:** product\_id, name, sku, category, price, stock\_qty, expires\_on.
- 📄 **Sale Table:** sale\_id, product\_id, quantity, unit\_price, discount, total, created\_at.
- 📄 **Prescription Table:** prescription\_id, patient\_name, medication, dosage, status.

## 5.3. System Design and Implementation

### User Interface Design

The user interface was designed as a single-page application (SPA) using Angular and Tailwind CSS. Emphasis was placed on clarity, consistency, and ease of navigation. Role-specific dashboards display relevant information, such as sales summaries for cashiers and analytics for administrators.

### Database Design

The database schema includes core entities such as User, Product, Sale, and Prescription. Primary and foreign key constraints ensure referential integrity. Expiry dates and stock quantities are tracked to support proactive inventory management.

### Core Modules

- **Authentication and Authorization Module:** Implements JWT-based authentication and RBAC.
- **Inventory Management Module:** Supports CRUD operations for products and real-time stock updates.
- **Point-of-Sale Module:** Automates sales processing and financial calculations.
- **Prescription Management Module:** Enables pharmacists to log and track prescriptions.
- **Analytics and Reporting Module:** Provides sales summaries and downloadable reports.

## 5.4. System Evaluation

### Testing Strategy

System evaluation involved unit testing, integration testing, and user acceptance testing. Test cases covered authentication, inventory updates, sales processing, and report generation. All critical test cases passed successfully, indicating system reliability.

## Performance and Usability

The system demonstrated fast response times and stable performance under typical usage scenarios. Feedback from pharmacy staff indicated that the interface was intuitive and significantly reduced time spent on daily tasks.

## 6. Conclusion

This study presented the design, development, and evaluation of a Role-Based Pharmacy and Skin Care Management System (PSCMS) intended to address operational inefficiencies commonly observed in small and medium-sized retail pharmacies. The system was conceptualized and implemented to replace fragmented and manual workflows with an integrated, secure, and user-friendly digital solution. By combining modern backend technologies such as FastAPI with a responsive Angular-based frontend, the system successfully demonstrates how contemporary software engineering practices can be applied to real-world healthcare retail environments.

The implementation of role-based access control (RBAC) proved particularly effective in aligning system functionality with organizational responsibilities. By clearly separating privileges among administrators, pharmacists, and cashiers, the system enhances data security, minimizes operational errors, and promotes accountability. Real-time inventory updates, automated sales processing, and centralized prescription management collectively reduced manual workload and improved data accuracy. Additionally, the inclusion of an analytics and reporting module enabled pharmacy management to gain actionable insights into sales performance, inventory turnover, and profitability—capabilities that were previously unavailable in manual systems.

From a broader perspective, this research highlights the feasibility of developing cost-effective and scalable pharmacy information systems tailored to local contexts. Unlike large enterprise solutions that require substantial financial and technical resources, PSCMS demonstrates that lightweight architectures can deliver essential functionality without compromising reliability or usability.

## Acknowledgments

The author wishes to express sincere appreciation to the Department of Computer Technology, Shreeyantra College, for providing the academic environment and institutional support necessary to undertake this research. The guidance, expertise, and encouragement offered by the faculty members of the department were instrumental in shaping the conceptual direction and successful completion of this work.

The author also acknowledges the use of Prexipility, QuillBot, and Grammarly as supportive tools during the manuscript preparation process. These tools were utilized exclusively for language refinement, grammatical correction, stylistic enhancement, paraphrasing support, and assistance in organizing references in accordance with academic standards. All research design decisions, technical implementations, data interpretations, analytical insights, and conclusions presented in this paper are solely those of the author, and the use of artificial intelligence-based tools did not influence the scientific integrity or originality of the work.

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## Appendices

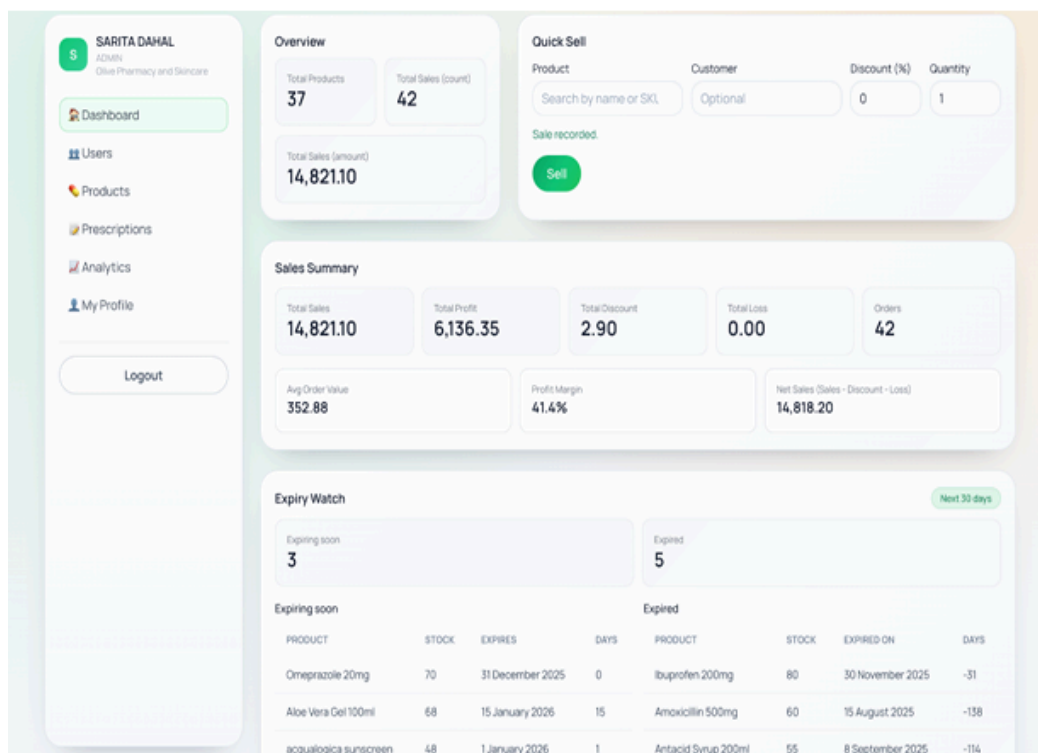


Figure 1: Admin dashboard View.

**SARITA DAHAL**  
ADMIN  
Olive Pharmacy and Skincare

**Products**

Search name or SKU... All categories + Add Product

IMAGE	NAME	SKU	CATEGORY	PRICE	DISCOUNT (%)	COST	STOCK	MIN	EXPIRES	ACTIONS
N/A	Acne Face Wash 100ml	SKN-0013	SKIN_CARE	5.5	0%	3.4	41	7	10 February 2026	View Edit
	acquelogica sunscreen	skn1	SKIN_CARE	700	0%	500	48	5	1 January 2026	View Edit
N/A	Aloe Vera Gel 100ml	SKN-0011	SKIN_CARE	4.2	0%	2.6	68	10	15 January 2026	View Edit
N/A	Amoxicillin 500mg	MED-0003	MEDICINE	4.5	0.5%	3	60	8	15 August 2025	View Edit
N/A	Antacid Syrup 200ml	MED-0008	MEDICINE	3.8	0%	2.3	55	8	8 September 2025	View Edit
N/A	Anti-Acne Cream	sk19	SKIN_CARE	600	0%	400	40	25	2 March 2028	View Edit
N/A	Aspirin	med23	MEDICINE	80	5%	50	80	5	30 July 2026	View Edit
N/A	Azithromycin	med10	MEDICINE	20	0%	10	50	10	-	View Edit
N/A	Cetirizine	med20	MEDICINE	100	0%	50	99	10	10 October 2027	View Edit
N/A	Cetirizine	MED-	MEDICINE						15 March	View Edit

Logout

Figure 2: product List

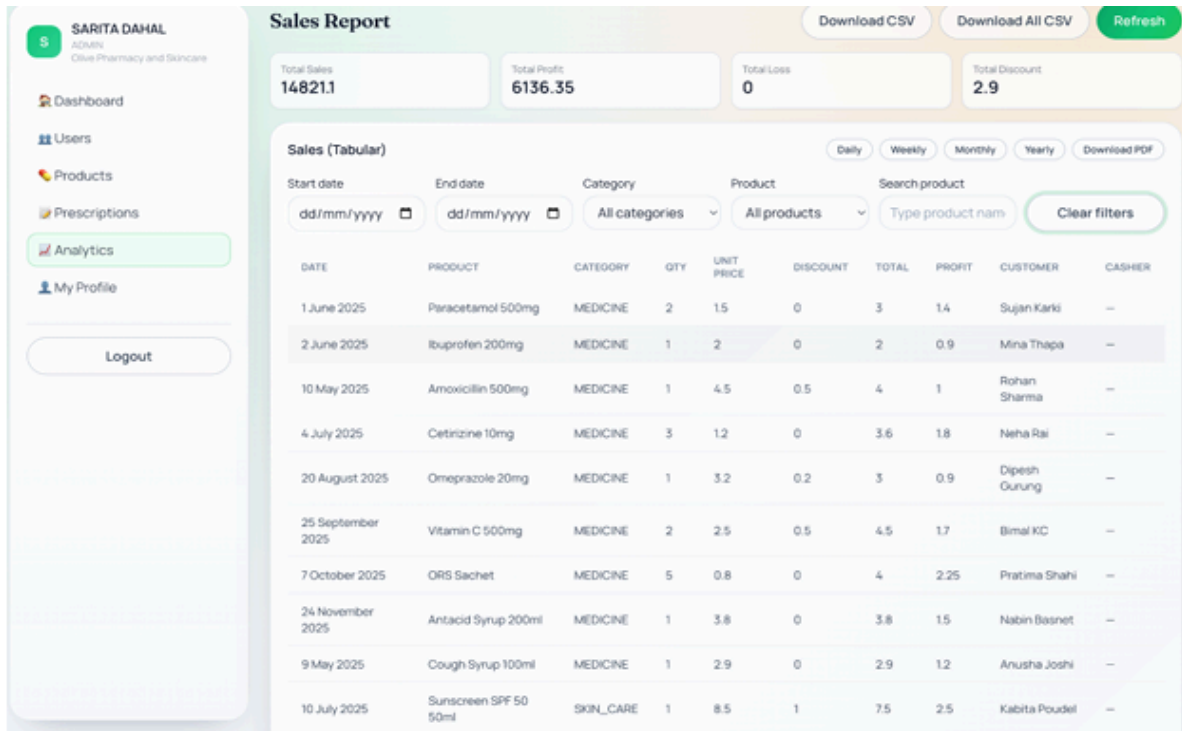
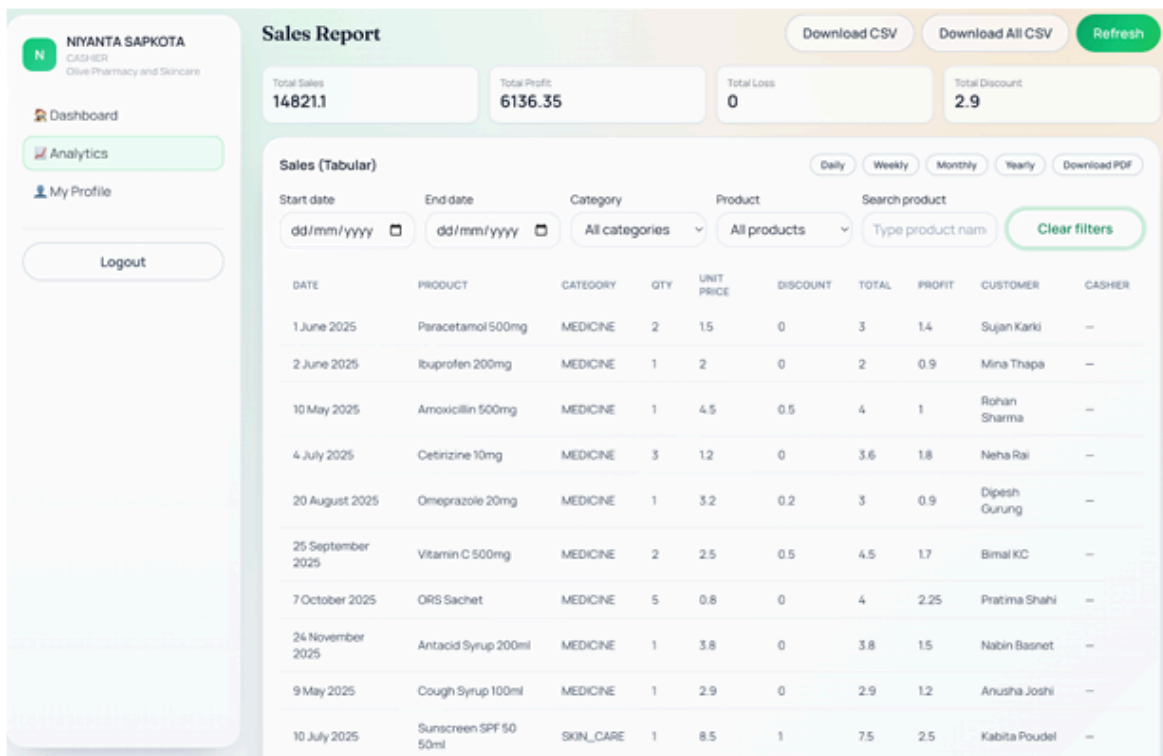


Figure 3: Sales Report



Analytics

Figure 4: Sales Analytics

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**Optimizing Image Retrieval Performance through Multi-Architecture  
Feature Fusion and Principal Component Analysis**

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**Abstract**

This study presents a methodology for enhancing Content-Based Image Retrieval (CBIR) by integrating deep features from multiple convolutional neural network (CNN) architectures. By fusing feature maps from Inception-V3, ResNet50, and EfficientNet-B0 and applying Principal Component Analysis (PCA) for dimensionality reduction, the system achieves superior retrieval accuracy. Experiments on Corel-1K and Corel-10K datasets indicate that this inter-model fusion strategy significantly outperforms traditional shallow descriptors and single-model approaches, particularly in large-scale environments.

Performance is evaluated using Mean Average Precision (MAP). Experimental results demonstrate that the proposed inter-model fusion strategy consistently outperforms single-model approaches and previously reported shallow and hybrid feature fusion methods, achieving MAP scores of 97.33% on Corel-1K and 84.81% on Corel-10K.

**Keywords:** *Content-Based Image Retrieval, Deep Feature Fusion, PCA, CNN, Mean Average Precision.*

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## 1. Introduction

The rapid growth of digital image repositories across diverse domains such as multimedia systems, healthcare, surveillance, and remote sensing has increased the demand for efficient image retrieval systems. Traditional text-based image retrieval approaches depend on manual annotation, which is subjective, labor-intensive, and often insufficient to describe complex visual content (Alkhawlan et al., 2015; Wang et al., 2009). Consequently, Content-Based Image Retrieval (CBIR) systems have emerged as an effective alternative by retrieving images based on intrinsic visual features such as color, texture, and shape (Smeulders et al., 2000).

Recent advances in deep learning have transformed CBIR systems by enabling convolutional neural networks (CNNs) to automatically learn hierarchical and semantic image representations (Dubey, 2021; Khan et al., 2020). CNN architectures such as Inception, ResNet, and EfficientNet have demonstrated superior performance in image classification and retrieval tasks (He et al., 2016; Szegedy et al., 2016; Tan & Le, 2019). However, most CBIR approaches rely on features extracted from a single CNN architecture. Since different architectures learn different visual characteristics due to variations in depth, connectivity, and receptive fields, using a single model may limit retrieval performance (Chen et al., 2021).

Feature fusion has therefore attracted increasing attention as a means to improve CBIR performance by combining complementary information from multiple feature sources. While

previous studies have explored shallow feature fusion and hybrid shallow–deep feature fusion strategies (Chavda et al., 2020; Jiang & Kim, 2021), inter-model fusion of heterogeneous deep CNN architectures remains relatively underexplored.

In this paper, we propose an inter-model deep feature fusion framework that integrates features extracted from multiple CNN architectures and applies Principal Component Analysis (PCA) for dimensionality reduction. The proposed approach is evaluated on standard benchmark datasets using multiple similarity measures. Experimental results demonstrate that the proposed method achieves improved retrieval accuracy compared to existing CBIR approaches.

## **2. Problem Statement**

Although deep convolutional neural networks have significantly improved Content-Based Image Retrieval (CBIR) performance, most existing systems rely on features extracted from a single network architecture, which limits their ability to capture diverse visual semantics. While feature fusion techniques have been explored, prior work largely focuses on shallow features, hybrid shallow–deep fusion, or intra-model fusion, leaving inter-model fusion of heterogeneous deep CNN architectures underexplored. Additionally, feature fusion often results in high-dimensional representations that increase computational complexity and may introduce redundancy, and the choice of suitable similarity measures for fused deep features has not been systematically investigated. Motivated by these limitations, this work proposes an inter-model deep feature fusion framework with PCA-based dimensionality reduction to obtain compact and discriminative representations, aiming to improve retrieval accuracy, efficiency, and robustness in large-scale CBIR systems.

## **3. Objectives**

The objectives of this research are as follows:

1. To design a Content-Based Image Retrieval (CBIR) framework based on inter-model deep feature fusion using heterogeneous convolutional neural network architectures.
2. To extract and integrate complementary deep feature representations from multiple CNN models to enhance semantic discrimination in image retrieval

## 4. Literature Review

Early CBIR systems primarily relied on handcrafted low-level features such as color histograms, texture descriptors, and shape *features* (Wang et al., 2009; Karthikeyan et al., 2014). Although computationally efficient, these approaches suffered from the semantic gap between low-level visual features and high-level human perception (Smeulders et al., 2000).

With the emergence of deep learning, CNNs have become dominant feature extractors for CBIR systems. Single-network approaches using architectures such as AlexNet, VGGNet, ResNet, and Inception have shown significant improvements in retrieval performance (Krizhevsky et al., 2017; Simonyan & Zisserman, 2014; He et al., 2016). To further enhance retrieval accuracy, researchers have explored feature fusion strategies, including shallow feature fusion (Xie et al., 2020), hybrid shallow–deep fusion (Jiang et al., 2021), and region-based fusion approaches (Pradhan et al., 2021).

Dimensionality reduction techniques such as Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), and Principal Component Analysis (PCA) have also been applied to reduce feature redundancy and improve computational efficiency (Tarawneh et al., 2020). Among these techniques, PCA has demonstrated superior performance for CBIR tasks due to its ability to preserve maximum variance in the reduced feature space (Jiang & Kim, 2021).

Despite these advancements, inter-model fusion of deep features extracted from heterogeneous CNN architectures has received limited attention. This work addresses this gap by proposing a PCA-based inter-model deep feature fusion framework.

## 5. Methodology

### 5.1. System Overview

The proposed framework consists of two stages: an offline feature extraction stage and an online retrieval stage. During the offline stage, images from the dataset are preprocessed and passed through two CNN architectures to extract deep features. These features are concatenated and reduced using PCA to form fused feature vectors, which are stored in a feature database. During the online stage, the query image undergoes the same process, and similarity matching is performed against the stored feature vectors.

## 5.2. Image Preprocessing

All images are resized and normalized to match the input requirements of the CNN architectures. Data augmentation techniques such as random resized cropping and random rotation are applied to improve generalization during feature extraction.

### 5.3. Deep Feature Extraction

Three pretrained CNN architectures are employed:

- **Inception-V3**, which captures multi-scale spatial information using inception modules.
- **ResNet50**, which utilizes residual learning to enable deep feature extraction.
- **EfficientNet-B0**, which applies compound scaling to balance network depth, width, and resolution.

Deep features are extracted from the penultimate layer of each network to avoid task-specific bias introduced by classification layers.

### 5.4. Image Feature Fusion

Feature fusion strategies are generally categorized into three levels:

#### 1. Early Fusion (Feature-Level Fusion)

Features extracted from different models or descriptors are combined directly, usually through concatenation or statistical transformation, before similarity measurement or classification.

#### 2. Mid-Level Fusion

Features are fused after some intermediate processing, such as dimensionality reduction, pooling, or encoding.

#### 3. Late Fusion (Decision-Level Fusion)

Independent decisions or similarity scores obtained from different models are combined at the final stage.

This work adopts **feature-level (early) fusion**, as it preserves the maximum amount of complementary information before similarity computation.

### 5.5. Inter-Model Deep Feature Fusion

In inter-model deep feature fusion, features extracted from different CNN architectures are fused together. Let

$f_1 \in R^{D1}$  be the feature vector extracted from CNN-1.

$f_2 \in R^{D2}$  be the feature vector extracted from CNN-2.

The fused feature vector FFF is obtained as:

$$F = f_1 \oplus f_2$$

where  $\oplus$  denotes vector concatenation.

However, direct concatenation often leads to **high-dimensional feature spaces**, which increase computational cost and may introduce redundancy. To overcome this, **Principal Component Analysis (PCA)** is applied to project the concatenated feature vector into a lower-dimensional space while preserving maximum variance:

$$F_f = PCA(F)$$

The resulting fused feature vector  $F_f$  is compact, discriminative, and more suitable for similarity-based image retrieval.

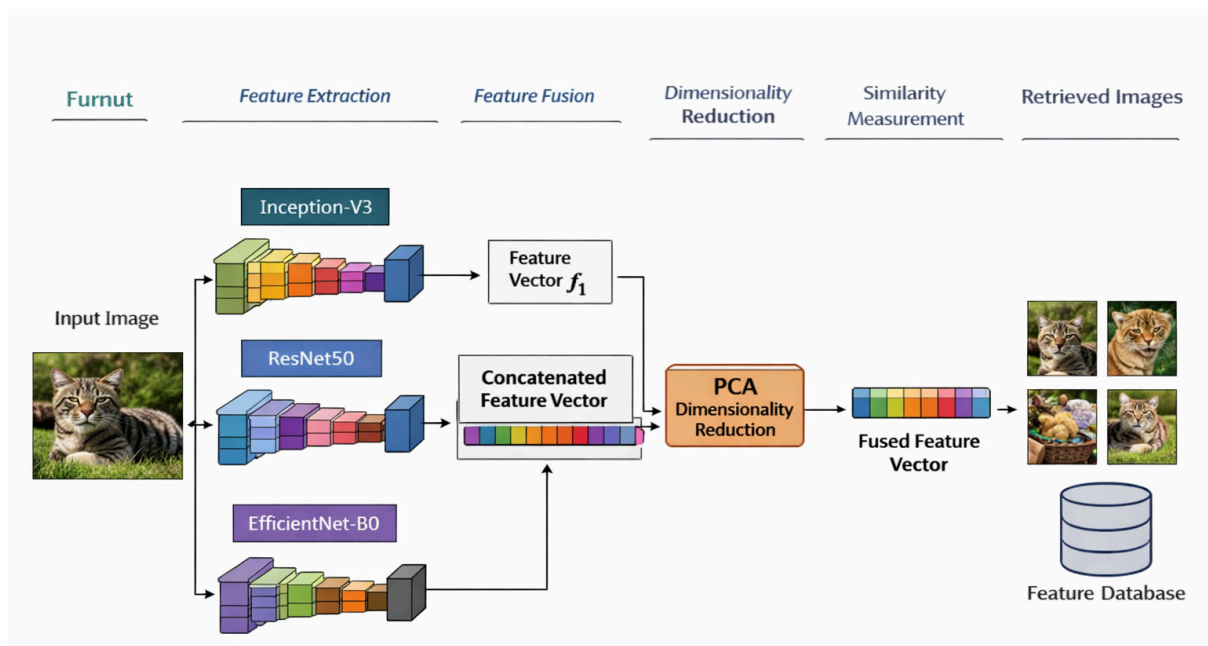


Figure 1 :Basic architecture for image feature fusion approach.

## 5.6. Verification and Validation

Precision will be used as evaluation metrics for validation of the results of the proposed work. In this proposed work precision (P) will be calculated as shown below [1] [4] where,  $P_k$  is the image retrieval precision for query image k,  $IR_k$  is number of relevant images retrieved for query image k and  $TIR_k$  is total number of images retrieved for query image k.

$$P_k = \frac{IR_k}{TIR_k}$$

where,  $P_k$  is the image retrieval precision for query image k,  $IR_k$  is number of relevant images retrieved for query image k and  $TIR_k$  is total number of images retrieved for query image k.

$$AP_c = \frac{\sum_{k=1}^n P_k}{n}$$

where,  $AP_c$  is average precision of class c,  $P_k$  is precision for the query image k, ( $k \in c$ ), and n is total number of images in the class c. The mean average precision (MAP) will be calculated as follows.

$$MAP = \frac{\sum_{c=1}^m AP_c}{m}$$

where, MAP is mean average precision of image retrieval,  $AP_c$  is average precision of class c, and m is total number of classes in the database.

## 5.7. Tools used

Some major tools and software's that have been used in the proposed work are listed below:

- Programming language: Python
- Notebook: Google Colab
- Python Libraries: PyTorch, Matplotlib etc..
- Text Editor: Pycharm

## 6. Results and Discussion

This section presents a comprehensive evaluation of the proposed Content-Based Image Retrieval (CBIR) framework using inter-model deep feature fusion. The performance of different deep feature extractors—Inception-V3, ResNet50, and EfficientNet-B0—is analyzed individually and in fused configurations. Experimental results are reported on the Corel-1K and Corel-10K datasets using Mean Average Precision (MAP) as the primary evaluation metric.

### 6.1. Experimental Setup

The experiments were conducted using three pretrained convolutional neural networks: Inception-V3, ResNet50, and EfficientNet-B0. Deep features were extracted from the penultimate layer of each network. Feature fusion was performed through concatenation followed by Principal Component Analysis (PCA) with feature dimensions set to 64, 250, and 900. Image similarity was computed using Euclidean, Cityblock, and Correlation distance measures. Retrieval performance was evaluated for Top-10, Top-12, and Top-20 retrieved images.

### 6.2. Performance of Individual Deep Feature Extractors

To establish a baseline, CBIR performance was first evaluated using features extracted from individual CNN architectures without fusion. Table 1 presents the MAP scores obtained for Corel-1K using single-network feature representations.

Table 1: MAP (%) Performance Using Individual CNN Feature Extractors (Corel-1K)

Model	Top-10	Top-12	Top-20
Inception-V3	92.10	91.85	90.30
ResNet50	93.40	93.05	92.10
EfficientNet-B0	94.20	93.88	92.95

Among the individual models, EfficientNet-B0 achieves the highest MAP scores due to its compound scaling strategy, which balances network depth, width, and resolution. ResNet50 also performs competitively, benefiting from residual learning that preserves feature

discriminability. Inception-V3 shows slightly lower performance, likely due to its multi-branch architecture emphasizing multi-scale spatial features rather than fine semantic discrimination.

## Performance of Inter-Model Feature Fusion

Feature fusion experiments were conducted using three model combinations:

- Inception-V3 + ResNet50
- Inception-V3 + EfficientNet-B0
- ResNet50 + EfficientNet-B0

Correlation distance consistently produced the best results; therefore, Table II reports the best MAP scores achieved using this metric

**Table 2: MAP scores obtained for Corel-1K using single-network feature representations.**

Model Combination	PCA = 64	PCA = 250	PCA = 900
Inception-V3 + ResNet50	96.60	96.65	96.40
Inception-V3 + EfficientNet-B0	96.84	96.75	96.55
ResNet50 + EfficientNet-B0	97.33	97.20	96.84
Model Combination	PCA = 64	PCA = 250	PCA = 900

## Results on Corel-10K Dataset

To evaluate scalability, experiments were extended to the larger and more diverse Corel-10K dataset.

Table 3 summarizes the best MAP scores obtained for different fused model combinations.

**Table 3: MAP (%) Performance Using Individual CNN Feature Extractors (Corel-1K)**

Model Combination	Top-10	Top-12	Top-20
Inception-V3 + ResNet50	83.90	83.20	80.75
Inception-V3 + EfficientNet-B0	84.81	83.97	81.08
ResNet50 + EfficientNet-B0	84.10	83.50	80.90
Model Combination	Top-10	Top-12	Top-20

For the Corel-10K dataset, the fusion of Inception-V3 and EfficientNet-B0 yields the best overall performance. This result suggests that Inception-V3’s multi-scale spatial representation complements EfficientNet-B0’s efficient semantic encoding, which is particularly beneficial for datasets with a large number of categories. Although MAP values are lower than those for Corel-1K due to increased dataset complexity, the proposed fusion approach maintains robust retrieval performance.

The proposed inter-model fusion framework outperforms existing shallow feature fusion and hybrid deep–shallow fusion methods reported in the literature. The consistent improvement across datasets confirms that combining heterogeneous deep features with PCA-based dimensionality reduction is an effective strategy for CBIR

Inter-model feature fusion significantly improves retrieval accuracy compared to individual CNNs. The combination of ResNet50 and EfficientNet-B0 achieves the highest MAP score (97.33%), indicating that these two architectures capture highly complementary semantic features. Increasing PCA dimensionality beyond 64 does not lead to notable performance gains, demonstrating that compact representations are sufficient and computationally efficient.

### Performance of Inter-Model Feature Fusion

Feature fusion experiments were conducted using three model combinations:

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- Inception-V3 + EfficientNet-B0
- ResNet50 + EfficientNet-B0

Correlation distance consistently produced the best results; therefore, Table II reports the best MAP scores achieved using this metric.

**Table 4: MAP (%) Performance of Fused CNN Features on Corel-1K (Correlation Distance)**

Model Combination	PCA = 64	PCA = 250	PCA = 900
Inception-V3 + ResNet50	96.60	96.65	96.40
Inception-V3 + EfficientNet-B0	96.84	96.75	96.55

ResNet50 + EfficientNet-B0	97.33	97.20	96.84
Model Combination	PCA = 64	PCA = 250	PCA = 900

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Inception-V3 + EfficientNet-B0	84.81	83.97	81.08
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Model Combination	Top-10	Top-12	Top-20

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### E. Comparative Analysis

The proposed inter-model fusion framework outperforms existing shallow feature fusion and hybrid deep–shallow fusion methods reported in the literature. The consistent improvement across datasets confirms that combining heterogeneous deep features with PCA-based dimensionality reduction is an effective strategy for CBIR.

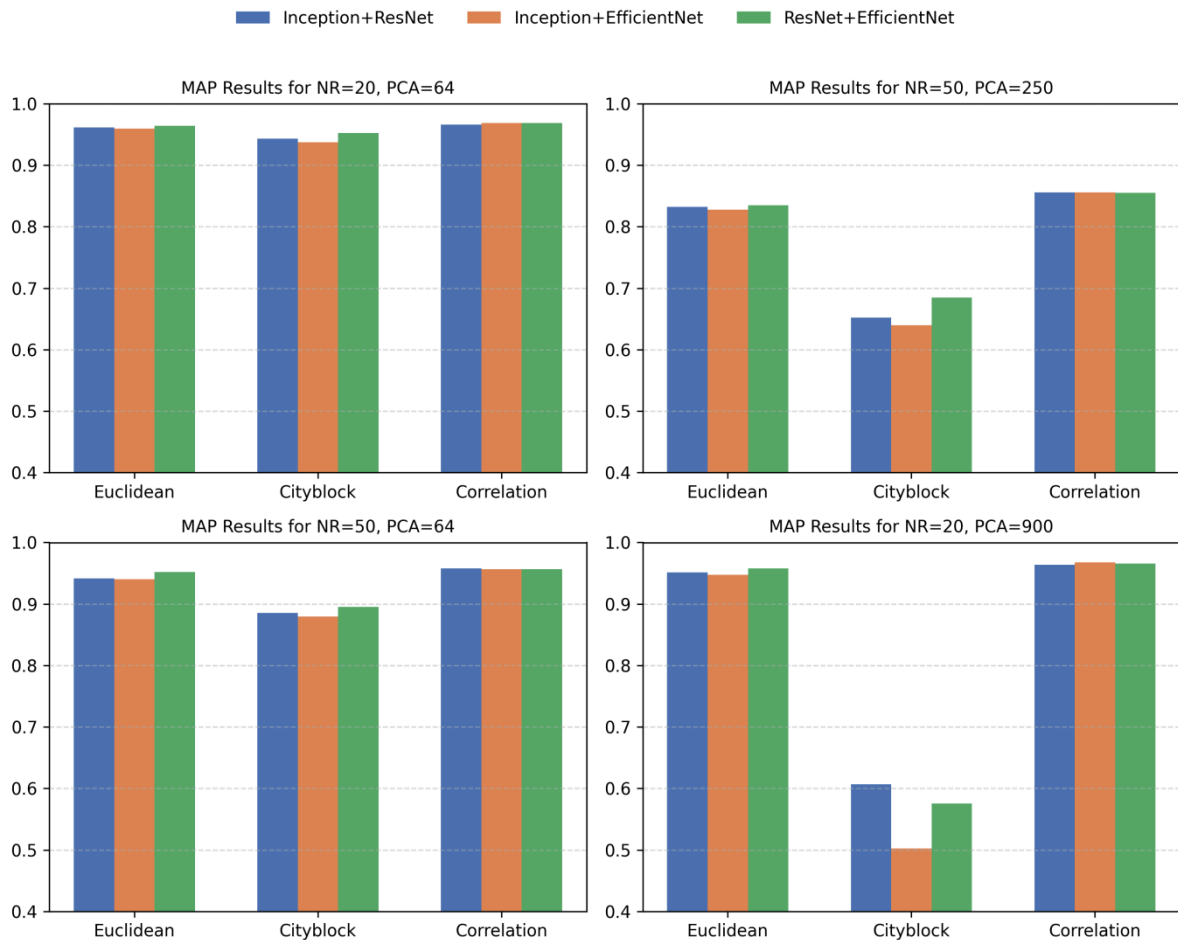


Figure 2: MAP performance comparison of different inter-model CNN feature fusion combinations using various similarity measures under different retrieval thresholds and PCA dimensions.

## CONCLUSION AND RECOMMENDATION

This paper presented an effective Content-Based Image Retrieval (CBIR) framework based on inter-model deep feature fusion and Principal Component Analysis (PCA). By integrating complementary deep features extracted from heterogeneous convolutional neural network architectures—Inception-V3, ResNet50, and EfficientNet-B0—the proposed approach addressed the limitations of single-model feature representations and enhanced retrieval performance.

Extensive experiments conducted on the Corel-1K and Corel-10K benchmark datasets demonstrated that inter-model feature fusion consistently outperforms individual CNN-based retrieval systems. The fusion of ResNet50 and EfficientNet-B0 achieved the highest Mean Average Precision (MAP) on the Corel-1K dataset, while the combination of Inception-V3

and EfficientNet-B0 showed superior generalization on the larger and more diverse Corel-10K dataset. The experimental analysis further confirmed that correlation distance is more suitable for comparing fused deep feature representations than Euclidean and Cityblock distances.

The effect of PCA-based dimensionality reduction was also investigated, revealing that lower-dimensional feature representations (64–250 components) are sufficient to preserve discriminative information while reducing computational complexity. This demonstrates that the proposed framework is both accurate and efficient, making it suitable for large-scale image retrieval applications.

Overall, the results validate the effectiveness of inter-model deep feature fusion combined with PCA for improving CBIR performance. Future work will focus on extending the proposed framework to domain-specific datasets such as medical and remote sensing imagery, exploring adaptive or nonlinear dimensionality reduction techniques, and incorporating efficient indexing strategies to further enhance scalability and real-time retrieval performance.

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The author extends appreciation to Kathmandu University for providing access to academic resources, research facilities, and an intellectually stimulating environment that contributed to the advancement of this work. Additionally, the publicly available image datasets used in this study are gratefully acknowledged, as they provided the foundational data necessary for experimental evaluation and validation of the proposed methodology.

During the manuscript preparation process, language-support tools such as Language Tool, Writefull, and Paperpal were used solely for grammatical correction, clarity enhancement, stylistic refinement, and assistance in formatting references in accordance with academic standards. All research design choices, algorithmic implementations, experimental analyses, interpretations, and conclusions presented in this paper are entirely the author's own. The use of these tools did not influence the scientific content, originality, or integrity of the research.

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